



# NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

**Modeling & Simulation Education for the  
Acquisition and T&E Workforce:  
FY07 Deliverable Package**

By  
Dr. David H Olwell  
Jean Johnson  
Stephanie Few  
Jarema M. Didoszak

**Approved for public release; distribution is unlimited**

Prepared for: DASN RDT&E  
1000 Navy Pentagon BF 963  
Washington, D.C. 20350

THIS PAGE INTENTIONALLY LEFT BLANK

**NAVAL POSTGRADUATE SCHOOL**  
**Monterey, California 93943-5000**

Daniel T. Oliver  
President

Leonard A. Ferrari  
Provost

This report was prepared for CAPT Mike Lilienthal, PhD, CPE, and funded by ASN (RDA) CHENG and the Modeling and Simulation Coordination Office (MSCO).

Reproduction of all or part of this report is authorized.

This report was prepared by:

---

Dr. David H. Olwell  
Chairman  
Systems Engineering Department

---

Jean Johnson  
Research Assistant  
Systems Engineering Department

---

Stephanie Few  
Research Assistant  
Systems Engineering Department

---

Jarema M. Didoszak  
Research Assistant Professor  
Mechanical Engineering Department

Reviewed by:

Released by:

---

Dr. David H. Olwell  
Chairman  
Systems Engineering Department

---

Dr. Dan C. Boger  
Interim Associate Provost and  
Dean of Research

THIS PAGE INTENTIONALLY LEFT BLANK

<b>REPORT DOCUMENTATION PAGE</b>			<i>Form Approved OMB No. 0704-0188</i>	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington DC 20503.				
<b>1. AGENCY USE ONLY (Leave blank)</b>		<b>2. REPORT DATE</b> December 2007	<b>3. REPORT TYPE AND DATES COVERED</b> Technical Report	
<b>4. TITLE AND SUBTITLE:</b> Workforce Modeling & Simulation Education and Training for Lifelong Learning: FY07 Deliverable Package			<b>5. FUNDING NUMBERS</b> N4814207WXMS703 N4814208WXMS804	
<b>6. AUTHOR(S)</b> Dr. David Olwell, Jean Johnson, Stephanie Few, Jarema Didoszak				
<b>7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)</b> Naval Postgraduate School Monterey, CA 93943-5000			<b>8. PERFORMING ORGANIZATION REPORT NUMBER</b> NPS-SE-08-M01	
<b>9. SPONSORING /MONITORING AGENCY NAME(S) AND ADDRESS(ES)</b> ASN (RDA) CHENG 1000 Navy Pentagon BF 963 Washington, D.C. 20350			<b>10. SPONSORING/MONITORING AGENCY REPORT NUMBER</b>	
<b>11. SUPPLEMENTARY NOTES</b> The views expressed in this report are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.				
<b>12a. DISTRIBUTION / AVAILABILITY STATEMENT</b> Approved for public release; distribution is unlimited.			<b>12b. DISTRIBUTION CODE</b> A	
<b>13. ABSTRACT (maximum 200 words)</b> <p>This technical report presents the deliverables for calendar year 2007 for the "Educating the Modeling and Simulation Workforce" project performed for the DoD Modeling and Simulation Steering Committee. It includes the results for spirals one and two. Spiral one is an analysis of the educational needs of the program manager, systems engineer, and test and evaluation workforces against a set of educational skill requirements developed by the project team. This is referred to as the 'learning matrix'. Spiral two is a set of module and course matrices, along with delivery options, that meets the educational needs identified in spiral one. This is referred to as the 'learning architecture'.</p> <p>Supporting materials, such as case studies and a handbook, are included.</p> <p>These documents serve as the design framework for spirals three and four, to be completed in CY2008, and which involve the actual production and testing of the courses in the learning architecture and their longitudinal assessment.</p> <p>This report includes the creative work of a seven university consortium and a group of M&amp;S stake-holders, together comprising over 60 personnel.</p>				
<b>14. SUBJECT TERMS</b> Modeling and Simulation, Education, Training, Acquisition, Systems Engineering, Life Cycle, Naval Postgraduate School			<b>15. NUMBER OF PAGES</b> 684	
			<b>16. PRICE CODE</b>	
<b>17. SECURITY CLASSIFICATION OF REPORT</b> Unclassified	<b>18. SECURITY CLASSIFICATION OF THIS PAGE</b> Unclassified	<b>19. SECURITY CLASSIFICATION OF ABSTRACT</b> Unclassified	<b>20. LIMITATION OF ABSTRACT</b> UL	

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)  
Prescribed by ANSI Std. Z39-18

THIS PAGE INTENTIONALLY LEFT BLANK

# Modeling and Simulation

## Educating the DoD Communities and Services



*Acquisition; Test and Evaluation*

## FY07 Deliverable Package

31 December 2007

By

Dr. David Olwell

Jean Johnson

Stephanie Few

Jarema M. Didoszak

**Approved for public release; distribution is unlimited.**

Prepared for: **DASN RDT&E**  
1000 Navy Pentagon BF 963  
Washington, D.C. 20350

**MIPR# DWAM70217**

## **Table of Contents**

<b>Executive Summary.....</b>	<b>3</b>
 <b>Part One: Project Overview</b>	
1.1 Stakeholder Group.....	6
1.2 Academic Partners.....	7
1.3 Project Roadmap .....	9
1.4 Educational Skill Requirements.....	10
1.5 Supplemental Material .....	12
1.6 Conferences and Workshops.....	13
 <b>Part Two: Work Products</b>	
2.1 Learning Matrix.....	14
2.2 Learning Architecture .....	65
2.3 Module Syllabi .....	67
2.4 Course Syllabi .....	368
2.4.1 Courses for Development.....	369
2.4.2 All Course Syllabi (by Academic Partner).....	430
2.5 Engineering Case Studies.....	646
2.6 Outline for Defense Acquisition Modeling and Simulation Guide.....	663
 <b>Part Three: Conclusion.....</b>	<b>679</b>
 <b>Appendix</b>	
I. Military Interdepartmental Purchase (MIPR).....	682
II. FY07 Statement of Work.....	683
 <b>Distribution List.....</b>	<b>685</b>



## **Executive Summary**

Goal 5 of the DoD M&S Strategic Vision is “To develop people that are well trained and employ existing models, simulation, and data to support departmental objectives.” This project specifically addresses Objective 5 of the Acquisition M&S Master Plan: Shape the Workforce, Action 5-1, and will eliminate gaps G-WFD-1, 2, and 3, identified in the 2006 MSSC C&CC BP.

To satisfy these identified needs, the Defense Modeling and Simulation Coordination Office presented the Naval Postgraduate School with an enormous challenge in 2006: design and deliver an educational program by 2008, for 20,000 or more acquisition professionals, focusing on the effective use of modeling and simulation in acquisition. The acquisition workforce is central to force transformation, and education is the key to transforming that workforce. This report presents the processes, participants, and 2007 deliverables for this project.

We applied a systems engineering approach to the problem of curricular design. The resulting solution consists of four spirals. The first spiral focused on defining the problem. We developed our analysis based on factors such as our market segmentation of the acquisition workforce, the current resources available, the state of the modeling and simulation body of knowledge, the desired educational outcomes for each market segment, and the gaps that existed between those outcomes and the existing resources. At each step in the process, we involved key stakeholders from the acquisition, test and evaluation and training communities. We describe the results of this process.

In the second spiral, our goal was to construct a learning architecture to cover the gaps identified in the first spiral. We describe the course content, scope, and delivery methods that we determined based on those needs from the first spiral.

The results of the first and second spirals, and subsequent lessons learned, are presented in this report. We will also briefly summarize the third and fourth spirals, which are currently underway, that involve course design and testing in the case of spiral three, and delivery and assessment of the curriculum for spiral four.

We found that there were educational gaps in the academic offerings across the United States. There were no programs or courses specifically to educate managers how to effectively employ M&S. We worked with stakeholders from the communities and services as well as partners from several key universities to develop a set of educational requirements to cover these gaps. We then designed modules and courses to meet these requirements. From the larger set, we focused on 16 courses that we will create in 2008.

Concurrent with our effort, the Air Force Agency for Modeling and Simulation (AFAMS) developed a human capital strategy for the M&S workforce and a consolidated body of knowledge. Their efforts are separately delivered.

These efforts are already bearing fruit. They are affecting the design and offering of M&S curricula at the academic partners, especially NPS, UCF, and JHU/APL. They have provided a roadmap to improve the education and training of the DoD workforce to better employ M&S.

With the completion of spirals three and four, the result of improving these skills through lifelong learning in M&S will be enhanced warfighting capability and decreased life cycle costs.

## **Acknowledgements**

We first acknowledge the central leadership and vision of CAPT Michael Lilienthal, who brought this opportunity to us. He provided the critical sponsor interface that freed us to concentrate on developing these products, while he fought the battles for funding and approval.

These deliverables are a team product. We acknowledge the contributions of our sponsors, academic partners, and stake-holders:

From NPS: Dr. Young Shin, Dr. Rudy Darken, Dr. Gene Paulo, Wanda Pan-Christiansen, Louis Algaze, Christina Fishback, John Dillard, Marshall Engelbeck, Ernest Koh, Joe Vaughan, Dr. Fotis A. Papoulias, Dr. Indranath Dutta, Dr. Sarath Menon, Dr. Young Kwon, Dr. Joshua H. Gordis, Dr. Peter C. Chu, Dr. Ramesh Kolar, Dr. John R. Lloyd, Dr. Oleg A. Yakimenko

From ODU: Dr. Marsha Gillis, Lisa Moya, Dr. Eric Weisel, Dr. Mike McGinnis, Mike Robinson, Sheila Flanagan

From UAH: Dr. Mikel Petty, Stacy Bradley, Dr. Jeffery Little

From GMU: James Campbell, Cynthia Huheey, Susan Stinson

From JHU/APL: Chris Ryder, Bob Lutz

From UCSD: Tony Genna, Sheila Romero, Dr. Bernie Ulozas

From UCF: Dr. Michael Proctor, CAPT Lik Chun, Dr. Peter Kincaid

From OSD: Mike Truelove, Chris Dipetto, Ed Weinberg, LtCol Nate White

From Department of the Navy: CAPT Mike Lilienthal, Steven Whitehead, Dr. Bill Rix, Kevin Charlow, Leslie Taylor, Amy Markowich, Tracey Johnston, LCDR Joseph Cohn, Dr. Nikhil Dave, John Isaacson, Bill Zimmerman

From Department of the Army: Gary Dahl, Oral Walker, Dr. Roger Smith, Philomena Zimmerman

From Department of the Air Force: Christina Juergens, Dr. Ed Degnan

From USCG: Dr. Diana Carl

From Industry: Gene Kochevar, Steve Cameron

## 1.1 Stakeholder Group

Our panel of stakeholders includes representation across the services. The Navy is represented by staff from the Secretary of the Navy's office, the Naval Air Systems Command, the Space and Naval Warfare Systems Command, and the Commander Operational Test and Evaluation Force. The Army is represented by staff from Headquarters, Department of the Army, and the Future Combat System Program Office. The Air Force is represented by the Air Force Agency for Modeling and Simulation and the Joint Strike Fighter Program Office. The Marine Corps has been represented by staff from the Expeditionary Fighting Vehicle Program Office. Industry has been represented by Boeing.

This group has been the primary creators and reviewers of the Educational Skill Requirements, which form the basis for the educational program under development.

The NPS project team first met with the stakeholders in January 2007. The initial meetings were focused on narrowing the scope of the effort to target the subset of the workforce with the greatest need for the educational program. Once this "market" was established, the team then focused on developing the high level Educational Skill Requirements (ESRs) for the program. This process was iterative, with an initial brainstorming period and several reviews that resulted in updates. The final ESR list was essentially established by the end of May 2007 and formed the basis of the requirements for the development of the program.

Once the ESRs were established, the stakeholder group became the advisors during the development of the project deliverables and reviewed the intermediate work products and final FY07 deliverables. Recommendations from the stakeholder group were incorporated throughout product development throughout the year. In September, an in-person review of the learning matrix (spiral one deliverable) was conducted, and in December, the learning architecture (spiral two deliverable) was reviewed over a series of teleconferences. Feedback from these meetings and other correspondence from the stakeholders were incorporated into the final products.

We have also thrice briefed the senior members of the Defense Modeling and Simulation Coordination Office on progress to date, and we have incorporated their feedback.

The project team recognizes that stakeholder inputs are critical to the success of the program. Ultimate success will be determined by the ability of the educational program to improve the capability of the workforce in applying M&S. This group of end user representatives is the most relevant source of feedback possible until students are able to sit through the course material. With that understanding, the project team has weighed heavily on their insights and course corrections throughout the development process.

## 1.2 Academic Partners

The target audience for these curricula is estimated at 20,000 students. This exceeds the capacity of any one educational institution. It also requires expertise from the best programs in the nation. To address this, we recruited partner schools from across the United States to participate in the project. Partners include the Defense Acquisition University, George Mason University, Johns Hopkins University / Applied Physics Lab, Old Dominion University, University of Alabama (Huntsville), University of California (San Diego), and the University of Central Florida. We have met and divided work among ourselves according to our specific competencies and strengths. For example, the University of Alabama (Huntsville) has a national reputation for its simulation based testing work, and that school volunteered to lead the design work for many of the T&E ESRs in Table 3. Together, this talented group is offering a program that will satisfy the needs set forth by the M&S CO and the NMSO.

Beginning in April 2007, the team began meeting to discuss the approach and way forward for providing the desired educational program. The Educational Skill Requirements developed by the stakeholders were as a basis for defining and distributing the work among the partners. Once the contracting process was complete and funding was in place, the partners proceeded to develop the learning architecture through a series of three task assignments.

1. Decompose ESR to next layer of detail - For each ESR, the partners provided a decomposition of the item into a greater level of detail. The decomposition provided a level of granularity sufficient to map the resulting educational requirements to specific workforce members and identify the desired knowledge level for each item.
2. Propose mapping of ESR substrata to workforce needs - For each lower level item in the decomposed ESRs, the partners provided a desired knowledge level (general awareness, understanding, application, and mastery) for each career group, namely Project Managers, Systems Engineers, and T&E workforce members, stratified by the following career levels: basic, intermediate and advanced. The development of these mappings was an iterative process between the developers, NPS, and the stakeholder groups, until a final product was developed. The results of these mappings were combined from each of the sources into one consolidated and cohesive Learning Matrix.
3. Develop Course Syllabi – The partners then developed module and course syllabi outlining the desired content of courses that will satisfy the needs identified in the Learning Matrix. These syllabi were combined from each source into a consolidated and cohesive Learning Architecture.

During product development, the academic partners met biweekly via teleconference to discuss progress and to obtain any necessary clarification throughout the process. Additionally, two in-person reviews of the intermediate work products were conducted. The first review, in September 2007, was a review of the initial learning matrix inputs from each of the partners. The detailed ESR decomposition and assigned competence

levels were discussed in detail, and modifications were made before presenting them to the stakeholders for feedback. The second review, held in November 2007, covered the learning architecture inputs. The module and course syllabi recommended by each school was presented and discussed.

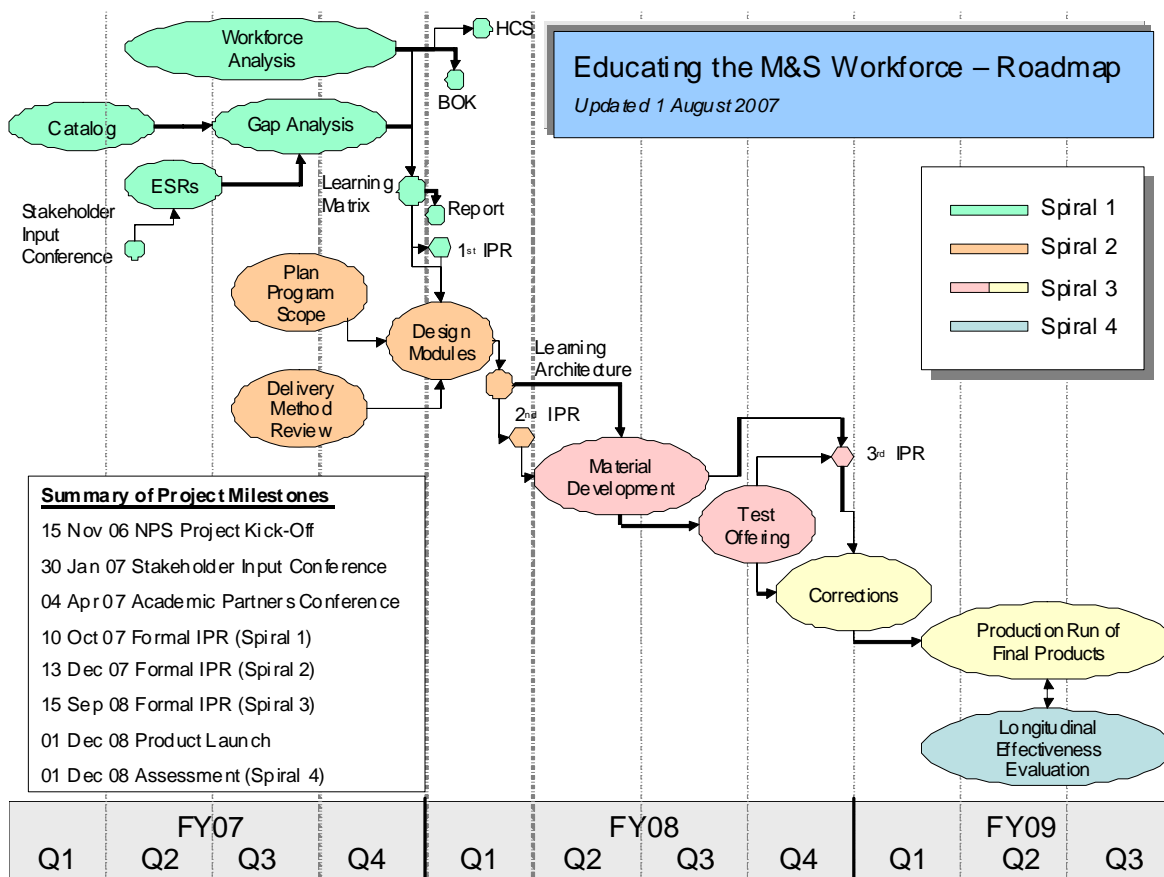
In the end, the academic partners produced a set of module syllabi that cover the materials for all of the ESRs, and a group of recommended course syllabi that cover a significant subset of the ESRs. The full course development of the recommended course syllabi will not be feasible in the next year's efforts due to budget and time constraints. Therefore, a subset of courses deemed most effective has been chosen and socialized with project sponsors and the stakeholder groups. The development of these courses will be the effort of the academic partners group over the next year.

## 1.3 The Project Roadmap

Figure 1.1 presents the timeline and interdependencies for the completion of this project. The color code listed on the graphic corresponds to the several different spirals of the project.

As of this report, all activities for spirals one and two have been completed and submitted.

This schedule was adjusted in August 2007 to slip a quarter due to the late receipt of funding and to unanticipated contracting issues with our academic partners.



**Figure 1.1 - Project Roadmap**

## 1.4 Educational Skill Requirements

We developed the detailed educational requirements for each of the nine market segments. Following terminology used at NPS, we called them “Educational Skill Requirements,” or ESRs for short. We identified key representatives from the user communities in government and industry. We also identified a set of potential academic partners for delivery and involved them in the requirement setting. The ESRs were broken into four areas, and they are presented below.

The ESRs were developed with the stakeholder team identified for the project. The stakeholders consist of representatives from the acquisition and T&E communities. The final list of ESRs has been presented at various venues for further feedback.

The Educational Skill Requirements are the basis for the instructional content for the program and were used as the key ingredient to the learning matrix and learning architecture products identified for spirals 1 and 2, described more fully below.

After consulting with our stakeholders, we broke the ESRs into five groups: process, program management, operations and logistics, test and evaluation, and engineering. The first group addressed common M&S issues for the acquisition community, and the last four addressed issues that focused on the corresponding domains of application.

The process ESRs contain several noteworthy tasks. They indicate that the integration of modeling and simulation as a source of data into formal decision making processes remains an important challenge for acquisition professionals. P5 requires the appropriate selection of a model and simulation for a given situation. P6 requires the student to establish and write valid modeling and simulation requirements. P7 requires the student to demonstrate project management skills for M&S activities, including cost estimation, scheduling, performance assessment, and risk identification and mitigation.

There was wide consensus that the skills and knowledge identified in the process ESRs were vital, and that it was of great importance to deliver these widely throughout the M&S workforce.

The engineering ESRs in Table 5 also deserve special comment. We observed that many in the acquisition community had a greater familiarity with operational models than with engineering models. Operational models are useful for verifying that the correct set of capabilities is defined in the concept development phase. Engineering models are useful for design, and especially for testing. In fact, if one desires to substitute M&S results for live testing, one is most often contemplating the use of an engineering model.

After long discussion and careful consideration of the audience, we decided that formal survey courses, one for each of the principles listed in Table 5, were not going to be palatable to the members of the acquisition community, who lacked the time and background to complete them successfully.



We decided to first address the engineering ESRs through a set of case studies that provide the engineering context as they presented the case. Accordingly, we commissioned preliminary design of eleven case studies. These range from the dynamics and control theory underlying the Segway machine, to the structural mechanics, fluid mechanics, and environmental science behind ship shock simulation models.

These case studies form the basis for a small set of survey courses that cover the engineering ESRs at the awareness level. These are discussed later in this report.

## 1.5 Supplemental Material

This section presents our progress to date on supplemental materials developed to support the larger project.

Early in our internal discussions among academic partners and stakeholders, we recognized that not all of the target audience would be amenable to taking academic courses. We developed a strategy to provide supplemental materials to provide other routes to get the knowledge into the hands of the workforce. These materials were also seen as a hedge against the possibility that the business models to move large numbers of students through courses were delayed: some content would still be available.

The first supplemental work is an update of the “System Acquisition Manager’s Guide to the Use of Models and Simulation” (Defense Systems Management College (DSMC), September 1994). This desktop reference had not been updated in 13 years. We revised the table of contents and sent out calls for updated contributions of papers and content. We plan to release the 2008 version by the fall. This should provide a useful desktop and electronic reference material to the acquisition workforce, as well as serving as a source document for our academic partners and their courses. A short summary is provided in section 2.6.

The engineering case studies constituted a second set of supplemental works. These were designed to stand alone in three forms. The first form was a collection of written case studies, which will be compiled into a text for publication. The second form was a collection of PowerPoint slides on each case, which are freely distributed to any academic or training institution to include in any courses they may use. The third form was a collection of web based, animated, and narrated presentations on the cases, using the briefings as a base. A report on the case studies, along with a representative set, is presented in section 2.5.

## 1.6 Conferences and Workshops

Throughout execution, we recognized the need to socialize the project goals and activities as much as possible. In addition to multiple opportunities to brief stakeholders and sponsor agencies, we participated in several conferences.

At the Defense Modeling and Simulation Conference, 7-10 May 2007, the project was presented during the Joint M&S Workforce Development Meeting. This meeting was conducted as the acquisition track Wednesday of the conference. The entire day was spent discussing and shaping the road ahead for the project.

We also presented the project at the NPS-hosted Acquisition Research Symposium May 16-17 in Monterey, CA.

We presented two presentations and one paper for the 10<sup>th</sup> Annual NDIA Systems Engineering Conference, 22-25 October 2007. For the M&S track, we presented the results from the requirements development spiral for feedback. During the Education Track, we focused on the process that is being used to develop the educational program. This also was the topic of our paper.

Finally, we provided a paper that presented our approach and preliminary lessons learned for the Interservice/Industry Training, Simulation and Education Conference (IITSEC), 26-29 November 2007.

Efforts to continue the proper socialization of the project will continue throughout. The next two scheduled appearances are the 2008 Defense Modeling and Simulation Conference in Orlando, March 11, 2008, and the Modeling and Simulation Leadership Summit in Hampton Roads, VA, in February. We will actively pursue other opportunities to spread awareness and understanding of the project including future IITSEC, Winter Simulation Conference, and Acquisition Research Symposium events.

## 2.1 Learning Matrix

The primary outcome of the first spiral, which focused on defining the requirements for the program, was a learning matrix. The Educational Skill Requirements (ESRs) developed by the stakeholders were first decomposed into a greater level of detail by academic partners. Then the learning matrix was composed based on three key elements:

1. Detailed ESR's
2. Workforce segmentation definitions (Follows DoD 5000.52M descriptions)
  - Career Fields - Project Managers, Systems Engineers, and T&E workforce
  - Career Levels - Basic/entry, intermediate/journeyman, and advanced/senior career levels
3. Competence Levels - Four competence levels defined and mapped to Bloom's taxonomy – General Awareness, Understand, Application, and Mastery

These tools were given to the academic partners to develop the matrix.

The learning matrix maps knowledge elements to desired proficiencies, or levels of competence, for each career field and level. The matrix was developed as a single excel spreadsheet for each high level ESR. The decomposed ESR's are assigned levels of competence for each workforce segment. Additionally, each assignment is supported by some justification of the level of competence desired for that workforce member. These justifications are captured as comments in the excel spreadsheets as shown in Figure 2.1.1. While these justifications do not translate well to printed documents, they are available by contacting the project team.

	P8) Know and require the best practices and standards in modeling and simulation as developed in key case studies.								
	P8.1	P8.2	P8.3	P8.4	P8.5	P8.6	P8.7	P8.8	P8.9
<b>PM</b>									
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	Application	General Awareness	General Awareness	General Awareness
Advanced	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	Application	Application	Application	Application
<b>SE</b>									
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	General Awareness	Understand	General Awareness	General Awareness	Understand	General Awareness	General Awareness	General Awareness	General Awareness
Advanced	General Awareness	Understand	General Awareness	General Awareness	Understand	General Awareness	General Awareness	General Awareness	General Awareness
<b>T&amp;E</b>									
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	General Awareness	General Awareness	General Awareness	General Awareness	Understand	General Awareness	General Awareness	General Awareness	General Awareness
Advanced	General Awareness	General Awareness	General Awareness	General Awareness	Application	Application	Application	Application	Application
Sub ESR ID	Sub ESR Objective								
P8.1	Identify best practices in M&S planning								
P8.2	Identify best practices in M&S tool development (requirements, conceptual modeling)								
P8.3	Identify best practices in M&S federation development (DIS, HLA, IEEE standards)								
P8.4	Identify best practices in software development as it applies to M&S (IEEE standards, configuration management, maturity model standards)								
P8.5	Identify best practices in VV&A (maturity model, IEEE standards)								
P8.6	Apply a M&S Support Plan to provide best use of M&S across stages of the acquisition life-cycle								
P8.7	Analyze a sample V&V report for inclusion of best practices in VV&A								
P8.8	Given a case study, analyze the benefit of M&S best practices across all components of the M&S development life-cycle								
P8.9	Given a case study, analyze the benefit of M&S best practices across all components of the acquisition life-cycle								

Figure 2.1.1 Learning Matrix Example (with Justifications)

This learning matrix presents a roadmap for the development of courses for each of the workforce segments. It also provides a useful starting point for discussions of certification, as it identifies the knowledge requirements by work force segment for the use of M&S in these positions.

	P1) Describe the role of modeling and simulation prior to the concept decision to identify and quantify capability gaps and to estimate how well new program concepts might address those gaps.				
	P1. 1	P1. 2	P1. 3	P1. 4	P1. 5
Basic	Genl Aware	Genl Aware	Genl Aware	Understand	Understand
Intermediate	Understand	Understand	Understand	Application	Application
Advanced	Understand	Understand	Understand	Application	Application
Basic	Genl Aware	Genl Aware	Genl Aware	Understand	Understand
Intermediate	Understand	Understand	Understand	Application	Application
Advanced	Understand	Understand	Understand	Application	Application
Basic	Genl Aware	Genl Aware	Genl Aware	Genl Aware	Genl Aware
Intermediate	Genl Aware	Genl Aware	Genl Aware	Genl Aware	Genl Aware
Advanced	Genl Aware	Genl Aware	Genl Aware	Genl Aware	Genl Aware

P1.1: Describe the JCIDS process prior to the Concept Decision.

P1.2: Identify the three types of Functional Analyses.

P1.3: Describe how M&S is used in each level of Functional Analysis.

P1.4: Identify the components of DOTMLPF.

P1.5: Describe how M&S is used for DOTMLPF determinations.

	P2) Assess the costs, benefits, and risks of using physical testing, modeling and simulation, and historical data to provide information for acquisition decisions.			
	P2. 1	P2. 2	P2. 3	P2. 4
Basic	Understand	Understand	Understand	Understand
Intermediate	Application	Application	Application	Application
Advanced	Application	Application	Application	Application
Basic	Understand	Understand	Understand	Understand
Intermediate	Application	Application	Application	Application
Advanced	Application	Application	Application	Application
Basic	Application	Application	Application	Application
Intermediate	Application	Application	Application	Application
Advanced	Application	Application	Application	Application

P2.1: Describe the cost of physical testing vis a vis modeling and simulation, and historical data analysis

P2.2: Describe the benefits of physical testing vis a vis modeling and simulation, and historical data analysis

P2.3: Describe the risks of physical testing vis a vis modeling and simulation, and historical data analysis

P2.4: Describe how physical test, M&S and historical data can be combined to provide effective decision support

	P4) (Partial) Apply M&S in different testing environments (Live, Virtual, and Constructive). Apply both standalone and interoperable simulations in appropriate situations. Select among different simulation interoperability standards when necessary.								
	P4.1	P4.2	P4.3	P4.4	P4.5	P4.6	P4.7	P4.8	P4.9
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	Application	Application	Application	Application	Application	Application	Application	Application	Application
Advanced	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand
Basic	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand
Intermediate	Mastery	Mastery	Mastery	Mastery	Application	Application	Application	Application	Application
Advanced	Application	Application	Application	Application	Application	Application	Application	Application	Application
Basic	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand
Intermediate	Mastery	Application	Application	Mastery	Application	Application	Application	Application	Application
Advanced	Application	Application	Application	Application	Application	Application	Application	Application	Application

P4.1 Define the different testing environments (live, virtual, and constructive) and compare the relative advantages and disadvantages of each environment for different product and system testing applications.

P4.2 Identify the attributes of an M&S application that determine whether a live, virtual, constructive, or a combination environment would be most appropriate, and the values for those attributes that indicate each type.

P4.3 List significant and widely used models, standalone simulations, interoperable simulations, data sets, and interoperability protocol standards applied in the different environments.

P4.4 Describe approaches to testing and validating models and simulations suitable for use in each of the environments, and identify degree of accuracy typically required in that environment.

P4.5 Define the differences between standalone and interoperable simulation and give examples of each that have been used

P4.7 List current simulation interoperability protocol standards and describe the advantages and disadvantages of each in each of the different environments.

P4.8 List existing resources in each of the environments, including model repositories, implemented federations of interoperable simulations, standalone simulations, standard object models, and accredited data sets, and describe the procedures for

P4.9 Describe case studies of successful test and acquisition M&S applications in each of the different environments.



	P5) Establish and write valid modeling and simulation requirements using a process that includes modeling and simulation needs analysis, generation of valid modeling and simulation requirements, functional decomposition and conceptual model development, and issuance of "built to" or "buy to" performance specifications. Understand how models and simulations evolve in fidelity, resolution, and scope as the program life cycle progresses.									
	P5.1	P5.2	P5.3	P5.4	P5.5	P5.6	P5.7	P5.8	P5.9	P5.10
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	Mastery	Mastery
Advanced	Understand	General Awareness	Understand	Understand	Understand	Understand	Understand	Understand	Mastery	Mastery
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	Understand	Application
Advanced	Understand	General Awareness	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Application
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	Mastery	Mastery
Advanced	Understand	General Awareness	Understand	Understand	Understand	Understand	Understand	Understand	Mastery	Mastery

- P5.1 Describe the M&S development and VV&A lifecycle (for COTS, GOTS, and new development M&S)
- P5.2 Identify the three domains of M&S requirements (user domain, problem domain, and simulation domain)
- P5.3 Describe the types of representational requirements (e.g., entities, actions, tasks, interactions, behaviors) in M&S and standard methods for capturing them (e.g. UML, conceptual model descriptions)
- P5.4 Describe how M&S requirements, representational requirements, acceptability criteria, and intended use support conceptual model development and validation
- P5.5 Describe the M&S process differences between legacy (no, minor & major modifications) and new development models
- P5.6 Describe the work products available in M&S development and their role in VV&A
- P5.7 Describe how M&S fidelity, resolution, and scope changes across the acquisition lifecycle (e.g., concept refinement to DT to OTA to OT to training)
- P5.8 Describe the role of acceptability criteria in the VV&A process and its relationship to M&S requirements
- P5.9 Given a case study, select those requirements which are appropriate for M&S
- P5.10 Given a case study and sample acquisition documents (TEMP, CDD, ICD, PSPEC), develop or evaluate requirements for M&S

	P6: M&S Plan Assessment and Risk Mitigation Strategy: Estimate the cost, develop a schedule, and assess a modeling and simulation plan. Identify the areas of risk and develop a mitigation strategy.					
	P6.1	P6.2	P6.3	P6.4	P6.5	P6.6
Basic	Understand	Understand	Understand	Understand	Understand	Understand
Intermediate	Understand	Application	Application	Application	Application	Application
Advanced	Mastery	Mastery	Mastery	Mastery	Mastery	Mastery
Basic	Understand	Understand	Understand	Understand	Understand	Understand
Intermediate	Understand	Application	Application	Application	Application	Application
Advanced	Mastery	Mastery	Mastery	Mastery	Mastery	Mastery
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Advanced	Understand	Understand	Understand	Understand	Application	Application

- P6.1 Demonstrate competency level described in above matrix to relate acquisition cost models to M&S and risk mitigation using M&S tools.
- P6.2 Demonstrate competency level described in above matrix to define measurable performance factors for a given case study.
- P6.3 Demonstrate competency level described in above matrix to define cost requirements and justifications as they relate to an M&S plan.
- P6.4 Demonstrate competency level described in above matrix to develop a schedule for a M&S plan.
- P6.5 Demonstrate competency level described in above matrix to assess effectiveness (cost and schedule) of a M&S plan.
- P6.6 Demonstrate competency level described in above matrix to develop a risk mitigation strategy for implementing a M&S plan.

	P7: Simulation Support Plan (SSP): Incorporate modeling and simulation, through a Simulation Support Plan (SSP) or similar process, into a Systems Engineering Plan (SEP) and a Test and Evaluation Master Plan (TEMP).								
	P7.1	P7.2	P7.3	P7.4	P7.5	P7.6	P7.7	P7.8	P7.9
Basic	General Awareness	General Awareness	Understand	General Awareness	General Awareness	General Awareness	Understand	Understand	Understand
Intermediate	Understand	Understand	Application	General Awareness	Understand	Understand	Application	Application	Application
Advanced	Application	Mastery	Mastery	Understand	Application	Application	Mastery	Mastery	Mastery
Basic	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand
Intermediate	Understand	Application	Application	Application	Application	Application	Mastery	Understand	Mastery
Advanced	Mastery	Mastery	Mastery	Mastery	Mastery	Mastery	Mastery	Mastery	Mastery
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	Understand	Understand	General Awareness	General Awareness
Intermediate	Understand	Understand	Application	Understand	Understand	Application	Application	Understand	Application
Advanced	Application	Application	Mastery	Understand	Application	Mastery	Mastery	Application	Mastery

- P7.1 Demonstrate competency level described in above matrix to define a Simulation Support Plan (SSP) and the relationship to using M&S for acquisition decisions.
- P7.2 Demonstrate competency level described in above matrix to show efficient use of SSP across life cycle phases of development.
- P7.3 Demonstrate competency level described in above matrix to show how an integrated SSP, SEP and TEMP can be leveraged to reduce risk, cost and schedule issues.
- P7.4 Demonstrate competency level described in above matrix to define elements of System of Systems (SOS) and interoperability across SSP.
- P7.5 Demonstrate competency level described in above matrix to incorporate the SSP into a System Engineering Plan (SEP).
- P7.6 Demonstrate competency level described in above matrix to integrate an SSP into a Test and Evaluation Master Plan (TEMP).
- P7.7 Demonstrate competency level described in above matrix to analyze the rationale for trade-off decisions and selections for SSP, SEP and TEMP.
- P7.8 Demonstrate competency level described in above matrix to manage M&S resources and documentation of SSP, SEP and TEMP.
- P7.9 Demonstrate competency level described in above matrix to create and analyze a case study encompassing SSP, SEP and TEMP.

	P8) Know and require the best practices and standards in modeling and simulation as developed in key case studies.								
	P8.1	P8.2	P8.3	P8.4	P8.5	P8.6	P8.7	P8.8	P8.9
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	Application	General Awareness	General Awareness	Mastery
Advanced	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	Application	Mastery	General Awareness	Mastery
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	General Awareness	Understand	General Awareness	General Awareness	Understand	General Awareness	Mastery	Mastery	General Awareness
Advanced	General Awareness	Understand	General Awareness	General Awareness	Understand	General Awareness	Mastery	Mastery	General Awareness
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	General Awareness	General Awareness	General Awareness	General Awareness	Understand	General Awareness	Mastery	General Awareness	General Awareness
Advanced	General Awareness	General Awareness	General Awareness	General Awareness	Application	Application	Mastery	General Awareness	General Awareness

P8.1 Identify best practices in M&S planning

P8.2 Identify best practices in M&S tool development (requirements, conceptual modeling)

P8.3 Identify best practices in M&S federation development (DIS, HLA, IEEE standards)

P8.4 Identify best practices in software development as it applies to M&S (IEEE standards, configuration management, maturity model standards)

P8.5 Identify best practices in VV&A (maturity model, IEEE standards)

P8.6 Apply a sample M&S Support Plan to provide best use of M&S across all stages of the acquisition life-cycle

P8.7 Analyze a sample V&V report for inclusion of best practices in VV&A

P8.8 Given a case study, analyze the benefit of M&S best practices across all components of the M&S development life-cycle

P8.9 Given a case study, analyze the benefit of M&S best practices across all components of the acquisition life-cycle

	P9) Know the models and simulations used in a given phase of the acquisition process, their inputs and outputs, and their capabilities and limitations.			
	P9. 1	P9. 2	P9. 3	P9. 4
Basic	Application	Application	Application	Application
Intermediate	Application	Application	Application	Application
Advanced	Application	Application	Application	Application
Basic	Application	Application	Application	Application
Intermediate	Application	Application	Application	Application
Advanced	Application	Application	Application	Application
Basic	Application	Application	Application	Application
Intermediate	Application	Application	Application	Application
Advanced	Application	Application	Application	Application

P9.1: Identify the five phases of the acquisition life cycle.

P9.2: Identify the principal M&S applications used in each of the five phases of the acquisition life cycle.

P9.3: Describe representative examples of M&S used for each type of application in each phase of the acquisition life cycle.

P9.4: List the inputs, outputs, capabilities and limitations of each example M&S.

	P10) Know the common terminology and high level roles and responsibilities, as well as the underlying philosophy, principles, and methodologies used in VV&A efforts, especially those applied in DoD.							
	P10. 1	P10. 2	P10. 3	P10. 4	P10. 5	P10. 6	P10. 7	P10. 8
Basic	Application	Application	Application	Understand	Genl Aware	Genl Aware	Genl Aware	Application
Intermediate	Application	Application	Application	Application	Application	Application	Application	Application
Advanced	Application	Application	Application	Application	Application	Application	Application	Application
Basic	Application	Application	Application	Application	Genl Aware	Genl Aware	Genl Aware	Application
Intermediate	Application	Application	Application	Application	Application	Application	Application	Application
Advanced	Application	Application	Application	Application	Application	Application	Application	Application
Basic	Application	Application	Application	Application	Genl Aware	Genl Aware	Genl Aware	Understand
Intermediate	Application	Application	Application	Application	Application	Understand	Understand	Understand
Advanced	Application	Application	Application	Application	Application	Understand	Understand	Understand

P10.1: Define the terms "verification," "validation," and "accreditation"

P10.2: Describe the purpose and expectations of VV&A

P10.3: Identify the VV&A key players

P10.4: Describe the VV&A key players roles and responsibilities

P10.5: Identify the documentation required in the VV&A process

P10.6: Identify the four categories of VV&A techniques

P10.7: Describe representative VV&A techniques from each category

P10.8: List pertinent VV&A references for DOD and representative services

	P11) Be able to correctly match the level of detail of a model with that of the information needed to support a decision, and understand the connection between the decision to be made and the estimation of measures from the model.							
	P11.1	P11.2	P11.3	P11.4	P11.5	P11.6	P11.7	P11.8
Basic	General Awareness	General Awareness	General Awareness	Understand	Understand	General Awareness	Understand	Understand
Intermediate	General Awareness	Understand	Understand	Understand	Mastery	Understand	Mastery	Mastery
Advanced	General Awareness	Understand	Understand	Understand	Mastery	Understand	Mastery	Mastery
Basic	General Awareness	General Awareness	General Awareness	Understand	Understand	General Awareness	Understand	Understand
Intermediate	General Awareness	Understand	Understand	Understand	Mastery	Understand	Mastery	Mastery
Advanced	General Awareness	Understand	Understand	Understand	Mastery	Understand	Mastery	Mastery
Basic	General Awareness	General Awareness	General Awareness	Understand	Understand	General Awareness	Understand	Understand
Intermediate	General Awareness	Understand	Understand	Understand	Mastery	Understand	Mastery	Mastery
Advanced	General Awareness	Understand	Understand	Understand	Mastery	Understand	Mastery	Mastery

P11.1 Define the level of detail, fidelity, aggregation, and disaggregation

P11.2 Understand intended use and specific use within the context of VV&A

P11.3 Describe the relationship between simulation level of detail and decision criteria

P11.4 Group models according to their levels of detail

P11.5 Given a case study and V&V report, identify the decision criteria that can be supported by M&S

P11.6 Understand the basic concepts of input and output analysis with respect to a simulations measures of effectiveness

P11.7 Given a case study, identify if the level of detail in a simulation output matches the decision criteria

Given a case study and sample V&V report assess if modifications of input and output parameters are appropriate for a

P11.8 specific use

	P12) Design a sound simulation study for a given set of objectives.					
	P12.1	P12.2	P12.3	P12.4	P12.5	P12.6
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	Understand	Understand	Understand	Understand	Understand	Understand
Advanced	Understand	Understand	Understand	Understand	Understand	Understand
Basic	Understand	Understand	Understand	Understand	Understand	Understand
Intermediate	Application	Application	Application	Application	Application	Application
Advanced	Mastery	Mastery	Mastery	Mastery	Mastery	Mastery
Basic	Understand	Understand	Understand	Understand	Understand	Understand
Intermediate	Application	Application	Application	Application	Application	Application
Advanced	Mastery	Mastery	Mastery	Mastery	Mastery	Mastery

- P12.1 Demonstrate competency level described in above matrix to formulate the problem, set objectives, and conceptualize the simulation model.
- P12.2 Demonstrate competency level described in above matrix to identify and collect input data, and design sound model construct - considering simulation alternatives and required complexity.
- P12.3 Demonstrate competency level described in above matrix to include verification and validation in the overall simulation study plan. Verification refers to the process of ensuring that the model is free from logical errors - that it does what it is intended to do. Validation is the determination that the model is accurate and ensures representation of the actual system or problem.
- P12.4 Demonstrate competency level described in above matrix to estimate measures of performance for the system designs that are being simulated through use of production runs and subsequent analysis.
- P12.5 Demonstrate competency level described in above matrix to document and report on program operation, progress, decisions made and achievement of objectives.
- P12.6 Demonstrate competency level described in above matrix to create and analyze a sound simulation case study.



	P13) Apply appropriate statistical techniques to the analysis of simulation output.									
	P13.1	P13.2	P13.3	P13.4	P13.5	P13.6	P13.7	P13.8	P13.9	P13.10
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	Application	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	Understand	Understand	Understand	Understand	Understand	Application	Understand	Understand	Understand	Understand
Advanced	Understand	Understand	Understand	Understand	Understand	Application	Understand	Understand	Understand	Understand
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	Application	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	Understand	Application	Application	Application	Application	Application	Application	Application	Application	Application
Advanced	Understand	Application	Application	Application	Application	Application	Application	Application	Application	Application
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	Application	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	Understand	Understand	Understand	Understand	Understand	Application	Understand	Understand	Understand	Understand
Advanced	Understand	Application	Application	Application	Application	Application	Application	Application	Application	Application

- P13.1 Understand transient and steady-state behavior of stochastic processes  
 P13.2 Apply statistical analysis for terminating simulations  
 P13.3 Apply statistical analysis for steady state parameters  
 P13.4 Apply statistical analysis for steady-state cycle parameters  
 P13.5 Apply methods for evaluating multiple measures of performance  
 P13.6 Apply plotting methods for analyzing data  
 P13.7 Apply hypothesis testing, ANOVA, and confidence intervals  
 P13.8 Apply methods for comparing multiple alternatives (e.g. ranking and selection)  
 P13.9 Understand the generation of random variates in computers and apply variance reduction techniques  
 P13.10 Understand experimental design and optimization and apply sensitivity analysis

	P14) Manage and reuse existing models, data, and simulations appropriately and assure that new products developed are designed and prepared for reuse.									
	P14.1	P14.2	P14.3	P14.4	P14.5	P14.6	P14.7	P14.8	P14.9	P14.10
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	Application	Application	Application	Application	Application	Application	Application	Application	Application	Application
Advanced	Understand	Understand	Application	Understand	Understand	Understand	Application	Understand	Application	General Awareness
Basic	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand
Intermediate	Application	Mastery	Application	Application	Application	Application	Application	Application	Application	Application
Advanced	Application	Application	Mastery	Application	Application	Application	Application	Mastery	Application	General Awareness
Basic	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand
Intermediate	Application	Application	Application	Mastery	Mastery	Application	Application	Application	Application	Application
Advanced	Understand	Understand	Understand	Application	Application	Understand	Understand	Application	Understand	General Awareness

P14.1 Define the different methods by which a model or simulation can be reused. (To explain reuse methods, they include: reapplying the model “as is” in a similar application; federating the model as a federate to a simulation federation using a simulation interoperability protocol, such as DIS, HLA, or TENA; composing the model as a component with other models using composability approaches such as common library or product line; and integrating the model as source code with other models using standard software engineering practices.)

P14.2 Given a model and a proposed reuse application for it, identify suitable methods to implement the reuse.

P14.3 Determine the level of effort required to reuse a model, data set, or simulation in various applications under different reuse methods.

P14.4 Determine whether a proposed reuse application of a model, data set, or simulation is appropriate or inappropriate based on modeling paradigm, level of resolution, and bounds of validity. (“Bounds of validity” refers scenarios or input values for which a model, data set, or simulation has been validated.)

P14.5 Identify the assumptions behind a model, data set, or simulation, and determine how those assumptions constrain appropriate reuse applications.

P14.6 List current simulation interoperability protocol standards, interoperability frameworks and middleware libraries, and composability approaches that support reuse, and describe the advantages and disadvantages of each.

P14.7 List existing resources available for reuse, including model repositories, implemented federations, standalone simulations, standard object models, and accredited data sets, and describe the procedures for searching for resources within repositories of them.

P14.8 Calculate the incremental level of effort required to make a model, data set, or simulation reusable, beyond that required to create it for single use.

P14.9 Identify the levels of conceptual interoperability possible between federated simulations, and describe the extent of functionality and reusability associated with each level.

P14.10 Describe case studies of successful reuse applications of commonly used models, data sets, and simulations, and the characteristics of those applications that made the reuse successful.

	P14) Manage and reuse existing models, data, and simulations appropriately and assure that new products developed are designed and prepared for reuse.						
	P14.1	P14.2	P14.3	P14.4	P14.5	P14.6	P14.7
Basic	General Awareness	General Awareness	General Awareness	Understand	General Awareness	Understand	Understand
Intermediate	Understand	General Awareness	General Awareness	Mastery	Understand	Mastery	Mastery
Advanced	Understand	General Awareness	General Awareness	Mastery	Understand	Mastery	Mastery
Basic	General Awareness	General Awareness	General Awareness	Understand	General Awareness	Understand	Understand
Intermediate	Understand	General Awareness	General Awareness	Mastery	Understand	Mastery	Mastery
Advanced	Understand	General Awareness	General Awareness	Mastery	Understand	Mastery	Mastery
Basic	General Awareness	General Awareness	General Awareness	Understand	General Awareness	Understand	Understand
Intermediate	Understand	General Awareness	General Awareness	Mastery	Understand	Mastery	Mastery
Advanced	Understand	General Awareness	General Awareness	Mastery	Understand	Mastery	Mastery

- P14.1 Understand key concepts for M&S reuse, component-based, and distributed simulations
- P14.2 Identify characteristics of new simulation development that make reuse more achievable
- P14.3 Identify sources for models that are available for reuse
- P14.4 Analyze cost versus benefit for reuse of legacy simulations
- P14.5 Describe V&V necessary for reuse of a simulation considering a new specific use
- P14.6 Given a case study and a sample of VV&A report, identify appropriate models for reuse from a set of legacy models
- P14.7 Given a case study and a sample of VV&A report, determine the most cost effective option considering reuse of legacy simulations and new simulation development

	P15) Manage the data strategy for an M&S effort including estimating the resources necessary to obtain sufficient data to populate the model.											
	P15.1	P15.2	P15.3	P15.4	P15.5	P15.6	P15.7	P15.8	P15.9	P15.10	P15.11	
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	Application	Application	Application	Application	Application	Application	Application	Application	Application	Application	Application	Application
Advanced	Understand	Understand	Understand	General Awareness	General Awareness	General Awareness	Application	Understand	Application	Application	Application	Application
Basic	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand
Intermediate	Application	Application	Application	Application	Application	Application	Mastery	Application	Application	Application	Application	Application
Advanced	Application	Application	Application	General Awareness	General Awareness	General Awareness	Application	Application	Application	Mastery	Mastery	Application
Basic	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand
Intermediate	Application	Application	Application	Application	Application	Application	Mastery	Application	Application	Application	Application	Application
Advanced	Understand	Understand	Understand	General Awareness	General Awareness	General Awareness	Application	Understand	Application	Mastery	Mastery	Application

P15.1 List the categories of data sets required (such as terrain databases, Ph/Pk tables, and sensor performance parameters) for typical model and simulation types.

P15.2 List the data requirements for typical test and acquisition M&S applications in terms of data sets, data volume, data availability, data accuracy, data classification, data storage media, and data archival.

P15.3 Identify existing data resources available for reuse, including both unauthenticated (for simulation testing) and authenticated (for actual test use) data, and describe the procedures for searching for resources within repositories of them.

P15.4 Define commonly used formats for documenting data (i.e., meta-data) and describe how to use each form to assess a data set's utility for a specific application.

P15.5 For each type of data used by models and simulations, define commonly used formats for structuring and encoding the data (e.g., XML for entity performance parameters or CTDB for terrain) and describe how the format supports correct and appropriate use and reuse of data sets so structured.

P15.6 Define concepts of data models (e.g., HLA object models), identify commonly used data models (e.g., HLA RPR FOM), and explain how data models relate to data sets.

P15.7 Establish proper security procedures for safeguarding classified data sets, both input and output, during and between simulation executions.

P15.8 Prepare for distribution of output data sets produced by simulation executions, including documenting data format, assumptions, accuracy, and applicability.

P15.9 Describe approaches, identify tools, and calculate resources required for converting data sets from one format to another (e.g., converting terrain data from DTED to CTDB) if needed for a particular M&S application.

P15.10 Calculate the resources necessary to acquire and create the data needed for a test or acquisition M&S application, based on data required for the simulation, existing data resources available, and data creation experiences.

P15.11 Describe case studies of successful data acquisition and creation for data-intensive applications of commonly used models, data sets, and simulations, and the characteristics of those applications that made the reuse successful.

	P15) Manage the data strategy for an M&S effort including estimating the resources necessary to obtain sufficient data to populate the model.							
	P15.1	P15.2	P15.3	P15.4	P15.5	P15.6	P15.7	P15.8
Basic	General Awareness	General Awareness	General Awareness	General Awareness	Understand	Understand	Understand	Understand
Intermediate	Understand	General Awareness	Understand	General Awareness	Mastery	Mastery	Mastery	Mastery
Advanced	Understand	General Awareness	Understand	General Awareness	Mastery	Mastery	Mastery	Mastery
Basic	General Awareness	General Awareness	General Awareness	General Awareness	Understand	Understand	Understand	Understand
Intermediate	Understand	General Awareness	Understand	General Awareness	Mastery	Mastery	Mastery	Mastery
Advanced	Understand	General Awareness	Understand	General Awareness	Mastery	Mastery	Mastery	Mastery
Basic	General Awareness	General Awareness	General Awareness	General Awareness	Understand	Understand	Understand	Understand
Intermediate	Understand	General Awareness	Understand	General Awareness	Mastery	Mastery	Mastery	Mastery
Advanced	Understand	General Awareness	Understand	General Awareness	Mastery	Mastery	Mastery	Mastery

- P15.1 Understand the role of data in M&S application and development
- P15.2 Identify common data formats for M&S applications
- P15.3 Understand fundamentals of good data management practices
- P15.4 Identify common sources of data for M&S and data repositories
- P15.5 Given a case study, identify the minimum data requirements for the decision context
- P15.6 Given a case study and a sample V&V report, evaluate whether the data validation is sufficient for the specific use
- P15.7 Given a case study and a sample V&V report, evaluate the impact and cost of low quality data on simulation output
- P15.8 Given a case study and V&V report, assess the impact and cost of data unavailability

	A1) Describe the types, role and value of formal Modeling and Simulations, and their various characterizations for application to systems management, particularly with regard to design, testing, training, production, cost estimation, manning, and logistical simulations.										
	A1. 1	A1. 2	A1. 3	A1. 4	A1. 5	A1. 6	A1. 7	A1. 8	A1. 9	A1.10	A1.11
Basic	Application	Application	Application	Application	Application	Application	Application	Application	Application	Application	Application
Intermediate	Application	Application	Application	Application	Application	Application	Application	Application	Application	Application	Application
Advanced	Application	Application	Application	Application	Application	Application	Application	Application	Application	Application	Application
Basic	Application	Application	Application	Application	Understand	Understand	Understand	Understand	Understand	Understand	Understand
Intermediate	Application	Application	Application	Application	Application	Application	Application	Application	Application	Application	Application
Advanced	Application	Application	Application	Application	Application	Application	Application	Application	Application	Application	Application
Basic	Application	Application	Application	Application	Understand	Application	Genl Aware	Genl Aware	Genl Aware	Genl Aware	Genl Aware
Intermediate	Application	Application	Application	Application	Understand	Application	Genl Aware	Genl Aware	Genl Aware	Genl Aware	Genl Aware
Advanced	Application	Application	Application	Application	Understand	Application	Genl Aware	Genl Aware	Genl Aware	Genl Aware	Genl Aware

A1.1: List the three types of models

A1.2: Describe the purpose and characteristics of each type of model

A1.3 List the three types of simulations

A1.4: Describe the purpose and characteristics of each type of simulation

A1.5 Describe how M&S is used in systems design

A1.6 Describe how M&S is used in systems testing

A1.7 Describe how M&S is used in systems training

A1.8 Describe how M&S is used in systems production

A1.9 Describe how M&S is used in systems cost estimation

A1.10 Describe how M&S is used in systems manpower integration

A1.11 Describe how M&S is used in systems logistics planning and execution

	A2) Define the critical decisions in the acquisition lifecycle and how/what M&S is used to inform those decisions in order to reduce the time, resources, and risks associated with the acquisition process.			
	A2. 1	A2. 2	A2. 3	A2. 4
Basic	Application	Understand	Understand	Understand
Intermediate	Application	Application	Application	Application
Advanced	Application	Application	Application	Application
Basic	Understand	Understand	Understand	Understand
Intermediate	Understand	Application	Application	Application
Advanced	Understand	Application	Application	Application
Basic	Understand	Understand	Understand	Understand
Intermediate	Understand	Understand	Understand	Understand
Advanced	Understand	Understand	Understand	Understand

A2.1: Identify the six critical decisions in the acquisition lifecycle.

A2.2: Describe primary and secondary types of M&S functions that support each critical decision.

A2.3: Identify the intended use of each type of M&S supporting the six critical decisions.

A2.4: Identify representative examples of each type of M&S supporting the six critical decisions.

	A2b) Understand non-DoD concepts of Simulation-Based Acquisition (SBA) across the entire program life cycle of commercial companies, in order to gain possible new insights into reducing the time, resources, and risks associated with the DoD acquisition process.					
	A2.1	A2.2	A2.3	A2.4	A2.5	A2.6
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	Understand	Understand	Understand	Understand	Understand	Understand
Advanced	Understand	Understand	Understand	Understand	Understand	Understand
Basic	Understand	Understand	Understand	General Awareness	Understand	Understand
Intermediate	Application	Application	Application	Understand	Application	Application
Advanced	Application	Application	Application	Understand	Application	Mastery
Basic	Understand	Understand	Understand	General Awareness	Application	Understand
Intermediate	Application	Application	Application	General Awareness	Application	Application
Advanced	Application	Application	Application	General Awareness	Application	Mastery

A2.1 Demonstrate competency to the level specified in matrix A2 of acquisition strategy metaphors found in commercial corporations world wide.

A2.2 Demonstrate competency to the level specified in matrix A2 of commercial case history of HOW M&S has been used to advance and sustain quality and distribute production world-wide by global commercial aircraft manufacturers from the foundation of aviation with the Wright brothers to the most current aircraft.

A2.3 Demonstrate competency to the level specified in matrix A2 of commercial case history of recent radical changes in HOW M&S has been used by a Global Automotive Company to radically alter their entire software infrastructure, re-train their work force, rapidly close and then surpass other Global Automotive Commercial Companies through the productivity and time to market gains made possible through M&S

A2.4 Demonstrate competency to the level specified in matrix A2 of commercial case history of HOW M&S as used by Commercial Pharmaceuticals and others and the Virtual Body research initiatives have contributed to multiple program savings.

A2.5 Demonstrate competency to the level specified in matrix A2 of commercial case history of change management issues and approaches as it relates to M&S adoption and proliferation.

A2.6 Demonstrate competency to the level specified in matrix A2 of commercial case history of the use of Computer Assisted System Engineering tools to describe the relationship within and between systems life cycles within a corporation and close gaps between those systems.



	A3) Evaluate M&S proposals, relative to measurable program contributions, and decide on the appropriate program office level of expenditure on M&S tools throughout the program life cycle. Distinguish whether custom or off-the-shelf products will be best suited for the program's purpose.							
	A3.1	A3.2	A3.3	A3.4	A3.5	A3.6	A3.7	A3.8
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	General Awareness	General Awareness	General Awareness	Understand	Understand	Application	Mastery	Mastery
Advanced	General Awareness	General Awareness	General Awareness	Understand	Understand	Application	Mastery	Mastery
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	General Awareness	General Awareness	General Awareness	Understand	Understand	Understand	Understand	Application
Advanced	General Awareness	General Awareness	General Awareness	Understand	Understand	Understand	Understand	Application
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	General Awareness	General Awareness	General Awareness	Understand	Understand	Application	Understand	Understand
Advanced	General Awareness	General Awareness	General Awareness	Application	Application	Understand	Understand	Understand

- A3.1 Define the role of M&S throughout the acquisition cycle (e.g., Concept Development, DT&E, OT&E, LFT&E, and operations and sustainment)
- A3.2 Describe the use of an M&S Support Plan throughout the acquisition cycle
- A3.3 Define and distinguish between legacy, developmental, GOTS and COTS M&S
- A3.4 Understand the V&V process and its impact on M&S usage, acceptability, and cost
- A3.5 Understand the benefit and application of M&S reuse across programs and across a single program's lifecycle
- A3.6 Apply a sample M&S Support Plan to provide best use of M&S across all stages of the acquisition life-cycle (P9.7)
- A3.7 Given a case study and sample M&S Support Plan, develop an M&S budget
- A3.8 Given a case study and sample M&S Support Plan, select between available legacy, developmental, GOTS and COTS M&S options

	A4) Recognize contracting issues for M&S products. Include considerations for intellectual property issues, delivery terms, maintenance responsibility, standards for documentation, open architecture, interoperability, reuse and other considerations.								
	A4.1	A4.2	A4.3	A4.4	A4.5	A4.6	A4.7	A4.8	A4.9
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	General Awareness	Understand	Understand	Understand	Understand	General Awareness	General Awareness	Understand	Mastery
Advanced	General Awareness	Understand	Understand	Understand	Understand	General Awareness	General Awareness	Understand	Mastery
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	General Awareness	Understand	Understand	Understand	Understand	General Awareness	General Awareness	Understand	Understand
Advanced	General Awareness	Understand	Understand	Understand	Understand	General Awareness	General Awareness	Understand	Understand
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	General Awareness	Understand	Understand	Understand	Understand	General Awareness	General Awareness	Understand	Mastery
Advanced	General Awareness	Understand	Understand	Understand	Understand	General Awareness	General Awareness	Understand	Mastery

- A4.1 Describe M&S as used during the acquisition cycle (e.g., concept development, concept refinement, DT&E, OT&E, LFT&E) milestones and events
- A4.2 Understand the role of M&S in system development (contractor and government)
- A4.3 Understand how the use of developer M&S data can be used to support concept down-select and concept refinement
- A4.4 Understand the role of V&V in determining the appropriate use of M&S
- A4.5 Understand how acquisition documents (TEMP, CDD, ICD, PSPEC) support M&S requirements definition
- A4.6 Describe how M&S fidelity, resolution, and scope changes across the acquisition lifecycle (e.g., concept refinement to DT to OTA to OT to training) (P6.12)
- A4.7 Identify best practices in M&S tool development (requirements, conceptual modeling) (P9.2)
- A4.8 Understand how M&S data can be used to support DT&E, OT&E, and LFT&E through the model-test-model approach
- A4.9 Given a case study, assess contractor deliverables to support M&S best practices and program decision requirements

	A5) Know where to find organizational M&S resources to identify the number and types of models currently in use, best practices from case studies, where they originated, how they might be leveraged in support of an acquisition program.					
	A5. 1	A5. 2	A5. 3	A5. 4	A5. 5	A5. 6
Basic	Genl Aware	Genl Aware	Application	Application	Genl Aware	Genl Aware
Intermediate	Genl Aware	Genl Aware	Application	Application	Genl Aware	Genl Aware
Advanced	Genl Aware	Genl Aware	Application	Application	Genl Aware	Genl Aware
Basic	Genl Aware	Genl Aware	Application	Application	Genl Aware	Genl Aware
Intermediate	Genl Aware	Genl Aware	Application	Application	Genl Aware	Genl Aware
Advanced	Genl Aware	Genl Aware	Application	Application	Genl Aware	Genl Aware
Basic	Genl Aware	Genl Aware	Application	Application	Genl Aware	Genl Aware
Intermediate	Genl Aware	Genl Aware	Application	Application	Genl Aware	Genl Aware
Advanced	Genl Aware	Genl Aware	Application	Application	Genl Aware	Genl Aware

A5.1: Identify the DoD and service M&S structure and organizations

A5.2: Describe the M&S Communities

A5.3: Describe the role of the M&S Information Analysis Center (MSIAC)

A5.4: Describe the role of the MSIAC helpdesk and how to contact it for information

A5.5: List the M&S Coordination Agents

A5.6: List other M&S resources

	A6) Access of the Modeling and Simulation Resource Repository as a primary source for information about and access to DoD models, simulations, data sources, algorithms, and other M&S resources in order to facilitate reuse and avoid duplication.			
	A6. 1	A6. 2	A6. 3	A6. 4
Basic	Application	Application	Application	Application
Intermediate	Application	Application	Application	Application
Advanced	Application	Application	Application	Application
Basic	Application	Application	Application	Application
Intermediate	Application	Application	Application	Application
Advanced	Application	Application	Application	Application
Basic	Application	Application	Application	Application
Intermediate	Application	Application	Application	Application
Advanced	Application	Application	Application	Application

A6.1: Describe the purpose of the MSRR

A6.2: Demonstrate proficiency in logging on to the various MSRRs

A6.3: Locate information in the MSRR for a specific model, simulation, data source, algorithm, or resource

A6.4: Describe the DoD philosophy of M&S reuse

	M&S in Decision Risk Analysis and Risk Mitigation: Use M&S to make informed engineering tradeoff analyses through the program's Decision Risk Analysis process. Apply experimental design, level of model detail, and M&S application as a pre-test prediction tool. Evaluate M&S outputs/measures.					
	A7.1	A7.2	A7.3	A7.4	P6.6	A7.5
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	General Awareness	General Awareness	General Awareness	Understand	Understand	General Awareness
Advanced	Understand	Understand	Understand	Application	Application	Understand
Basic	Understand	Understand	Understand	Understand	Understand	Understand
Intermediate	Application	Application	Application	Application	Application	Application
Advanced	Mastery	Mastery	Mastery	Mastery	Mastery	Mastery
Basic	Understand	Understand	Understand	Understand	Understand	Understand
Intermediate	Application	Application	Application	Application	Application	Application
Advanced	Application	Application	Application	Application	Application	Application

- A7.1 Demonstrate competency level described in above matrix to develop pre-test criteria and analyze/apply choices of design detail for desired performance factors for a selected application.
- A7.2 Demonstrate competency level described in above matrix to analyze outputs/measures from M&S tools for a given case study.
- A7.3 Demonstrate competency level described in above matrix to evaluate performance factors and interdependencies of outputs/measures for a given case study.
- A7.4 Demonstrate competency level described in above matrix to identify and prioritize risk factors using the Decision Risk Analysis process.
- A7.6 Demonstrate competency level described in above matrix to develop a risk mitigation strategy for a given case study.
- A7.5 Demonstrate competency level described in above matrix to perform informed engineering tradeoff analyses through the Decision Risk Analysis process.

	T1: Quantify the risk of using M&S in place of live testing. For open systems, quantify the risk of using M&S to evaluate a single system component in place of testing an entire configuration.								
	T1.1	T1.2	T1.3	T1.4	T1.5	T1.6	T1.7	T1.8	T1.9
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand
Advanced	Understand	Understand	Application	Application	Application	Application	Application	Application	Application
Basic	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand
Intermediate	Application	Application	Application	Application	Application	Application	Application	Understand	Understand
Advanced	Application	Mastery	Application	Mastery	Application	Application	Application	Application	Application
Basic	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand
Intermediate	Application	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand
Advanced	Application	Application	Mastery	Application	Mastery	Mastery	Mastery	Application	Application

T1.1 Describe the roles, uses, limitations and trends of models and simulations of various types.

T1.2 Identify how M&S is used in systems engineering and decision support for T&E.

T1.3 Identify how M&S is used in a system's lifecycle for all phases of test and evaluation.

T1.4 Identify appropriate simulation use and model fidelity for systems validation.

T1.5 Identify the restrictions, applications, limitations, and risk reduction of M&S during T&E.

T1.6 Describe the risks of using M&S to evaluate a single system component in place of testing an entire configuration.

T1.7 Describe the levels of risk in testing and how M&S can be applied in risk reduction.

T1.8 Evaluate acceptable risk involving the use of M&S in testing.

T1.9 Describe the use of M&S for risk analysis and mitigation.

	T2: Integrate M&S, live test, prototype data, historical data, component data, and scale model data into a coherent test.									
	T2.1	T2.2	T2.3	T2.4	T2.5	T2.6	T2.7	T2.8	T2.9	T2.10
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand
Advanced	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand
Basic	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand
Intermediate	Application	Application	Application	Application	Application	Application	Application	Application	Application	Application
Advanced	Application	Application	Application	Application	Application	Application	Application	Application	Application	Application
Basic	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand
Intermediate	Application	Application	Application	Application	Application	Application	Application	Application	Application	Application
Advanced	Mastery	Application	Mastery	Mastery	Mastery	Mastery	Application	Application	Mastery	Mastery

T2.1 Define the types of simulation used in T&E.

T2.2 Describe how to use the Data Source Matrix (DSM) to identify all test and simulation events and allocate MOEs/MOPs to those events.

T2.3 Identify appropriate use of M&S to plan tests, to complement system live tests, and to evaluate joint capabilities.

T2.4 Identify and define various types of data.

T2.5 Describe how M&S can be used to develop and refine test scenarios and data matrices to obtain maximum data from limited test resources.

T2.6 Identify and describe actual examples of M&S integrated with T&E in the evaluation strategy.

T2.7 Describe and give examples of Live and M&S integration.

T2.8 Describe the Model-Test-Model methodology and list its benefits.

T2.9 Identify issues and opportunities relevant to the integrated use of simulation and testing.

T2.10 Describe how results from M&S are integrated with results from other sources, such as live-fire, historical data, operational data, etc.

	T3) Describe the different types of testing (i.e. unit, integration, developmental, interoperability, operational, and live fire testing) and identify the utility, limitations and risks for use of M&S in each. Understand the critical interrelationships and balance between modeling and simulation and more traditional forms of test and evaluation (T&E).								
	T3.1	T3.2	T3.3	T3.4	T3.5	T3.6	T3.7	T3.8	T3.9
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	Understand	Understand	Understand	Understand	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Advanced	Application	Application	Application	Application	Application	Application	Application	Application	Application
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand
Advanced	Application	Application	Application	Mastery	Application	Application	Application	Application	Application
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand
Advanced	Mastery	Mastery	Mastery	Mastery	Mastery	Mastery	Mastery	Application	Application

T3.1 Identify common types of testing and the inclusion of M&S in each.

T3.2 Identify the components and structure of integration testing and the place for M&S in this structure.

T3.3 Describe test procedures for M&S-base testing in each type (DT, OT, IT, etc) and sub-type (LUT, IOT, FOT, etc) of testing.

T3.4 Describe the evolutionary test process within the SE process and how M&S supports it.

T3.5 Describe and provide examples of types of operational testing and M&S appropriate use.

T3.6 Describe and provide examples of unit testing and M&S appropriate use.

T3.7 Identify the phases of interoperability testing and M&S appropriate use.

T3.8 Describe the relationship between testing and evaluation.

T3.9 Describe how M&S can be used in testing and evaluation.



	T3) Describe the different types of testing (i.e. unit, integration, developmental, interoperability, operational, and live fire testing) and identify the utility, limitations and risks for use of M&S in each. <i>Understand the critical interrelationships and balance between modeling and simulation and more traditional forms of test and evaluation (T&amp;E).</i>				
T3B	A8. 1	A8. 2	A8. 3	A8. 4	A8. 5
Basic	Application	Application	Understand	Application	Application
Intermediate	Application	Application	Understand	Application	Application
Advanced	Application	Application	Understand	Application	Application
Basic	Application	Application	Understand	Application	Application
Intermediate	Application	Application	Understand	Application	Application
Advanced	Application	Application	Understand	Application	Application
Basic	Application	Application	Application	Application	Application
Intermediate	Application	Application	Application	Application	Application
Advanced	Application	Application	Application	Application	Application

A8.1: List the three types of T&E

A8.2: Describe M&S requirements in T&E as listed in DoD 5000.2

A8.3: Describe the philosophy of M&S in testing

A8.4: Describe how M&S supplements live testing

A8.5: List the T&E requirement documents for the student's Service

	T4) Identify strategies for M&S use in the test planning and execution process.							
	T4.1	T4.2	T4.3	T4.4	T4.5	T4.6	T4.7	T4.8
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand
Advanced	Mastery	Mastery	Application	Mastery	Mastery	Application	Mastery	Application
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand
Advanced	Application	Application	Application	Application	Application	Application	Application	Application
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand
Advanced	Mastery	Application	Application	Mastery	Mastery	Mastery	Application	Mastery

T4.1 Describe the elements, including the use of M&S, of a Test and Evaluation Master Plan (TEMP).

T4.2 Describe relationship and purposes of the TEMP, System Evaluation Plan (SEP), and test/simulation execution strategy (T/SE).

T4.3 Describe the personnel, scope, approach, resources, and schedule for M&S of intended testing activities.

T4.4 Describe the forms of use of simulation in support of test planning, test execution, and systems analysis.

T4.5 Identify M&S strategies to optimize the use of scarce resources in executing test and evaluation programs.

T4.6 Describe how to use M&S to enable better test planning for operational live tests.

T4.7 Describe the life-cycle costs and its relationship to M&S in the context of T&E.

T4.8 Describe how M&S specifically supports pre-test planning, test execution, and performance reporting.

	T5) Match existing M&S T&E facilities used within the DoD to a given program need, as appropriate.					
	T5.1	T5.2	T5.3	T5.4	T5.5	T5.6
Basic	General Awareness	Understand	Understand	Application	Application	Application
Intermediate	General Awareness	Application	Application	Application	Application	Application
Advanced	General Awareness	Application	Mastery	Mastery	Mastery	Mastery
Basic	General Awareness	Understand	Understand	Application	General Awareness	General Awareness
Intermediate	General Awareness	Application	Application	Application	Understand	Understand
Advanced	General Awareness	Application	Mastery	Mastery	Understand	Understand
Basic	General Awareness	Understand	General Awareness	Application	General Awareness	General Awareness
Intermediate	General Awareness	Application	General Awareness	Application	General Awareness	General Awareness
Advanced	General Awareness	Application	General Awareness	Mastery	Understand	Understand

T5.1 List the key facilities which support DoD M&S T&E (including Major Shared Resource Centers).

T5.2 Describe the missions of the key facilities which support DoD M&S T&E.

T5.3 List and link the principle DoD customers to the key facilities which support DoD M&S T&E.

T5.4 Update and list current capabilities (strengths and weaknesses) of the key facilities which support DoD M&S T&E.

T5.5 Predict improvement and modernization activities of the key facilities which support DoD M&S T&E.

T5.6 Describe emerging facilities (currently under development) which will support DoD M&S T&E.

	O1) Describe the use of operational and logistical models across the acquisition life cycle.										
	O1.1	O1.2	O1.3	O1.4	O1.5	O1.6	O1.7	O1.8	O1.9	O1.10	O1.11
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	General Awareness	Understand	Understand	Understand	Understand	Understand	General Awareness	General Awareness	General Awareness	Mastery	Mastery
Advanced	General Awareness	Understand	Understand	Understand	Understand	Understand	General Awareness	General Awareness	General Awareness	Mastery	Mastery
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	General Awareness	Understand	Understand	Understand	Understand	Understand	General Awareness	General Awareness	General Awareness	Application	Application
Advanced	General Awareness	Understand	Understand	Understand	Understand	Understand	General Awareness	General Awareness	General Awareness	Application	Application
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	General Awareness	Understand	Understand	Understand	Understand	Understand	General Awareness	General Awareness	General Awareness	Mastery	Mastery
Advanced	General Awareness	Understand	Understand	Understand	Understand	Understand	General Awareness	General Awareness	General Awareness	Mastery	Mastery

- O1.1 Identify the acquisition cycle milestones and events supported by logistics and operational modeling applications
- O1.2 Understand the use of logistics and operational models in support of concept refinement by rapid prototyping
- O1.3 Understand the use of logistics and operational models in support of system development & demonstration to support system of systems and family of systems evaluations, to focus test and evaluation, and to support transfer to production
- O1.4 Understand how the use of logistics and operational models in support technology development reduces technology risk, allows the early evaluation of RM&A, transportability, and provisioning, and supports test & evaluation
- O1.5 Understand the use of logistics and operational models in support of production & deployment to streamline production and to support the development of trainers
- O1.6 Understand the use of logistics and operational models in support of operations and support to refine system design and identify future requirements
- O1.7 Describe types of operations analyses and the levels of detail typically included in these analyses (e.g., system, engagement, mission, campaign)
- O1.8 Describe types of logistics analyses (technical effectiveness, system effectiveness, system availability, operational availability, operational reliability, response time, workload allocation, and supply chain management) and the levels of detail typically included in these analyses
- O1.9 Describe the role of modeling inputs and assumptions in developing a logistics and an operational analysis (scenario & threat, missions, alternatives, required input data, operations concept, basing & deployment, support concept, [MAIS AoA: organizational missions, functions, & objective]).
- O1.10 Given a case study and a sample M&S Support Plan, assess the effectiveness of the M&S Support Plan in integrating M&S use throughout the lifecycle of the program through M&S reuse and the building of better models through the model-test-model approach
- O1.11 Given a case study, assess how models developed during the acquisition process can be used to support course-of-action, decision support, and training

	O2) Know the properties of a representative suite of operational models across the services.								
	O2.1	O2.2	O2.3	O2.4	O2.5	O2.6	O2.7	O2.8	O2.9
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	General Awareness	General Awareness	General Awareness	Understand	Understand	Understand	General Awareness	Understand	Mastery
Advanced	General Awareness	General Awareness	General Awareness	Understand	Understand	Understand	General Awareness	Understand	Mastery
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	General Awareness	General Awareness	General Awareness	Understand	Understand	Understand	General Awareness	Understand	Application
Advanced	General Awareness	General Awareness	General Awareness	Understand	Understand	Understand	General Awareness	Understand	Application
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	General Awareness	General Awareness	General Awareness	Understand	Understand	Understand	General Awareness	Understand	Mastery
Advanced	General Awareness	General Awareness	General Awareness	Understand	Understand	Understand	General Awareness	Understand	Mastery

- O2.1 Identify levels of detail typically included operational analyses (e.g., system, engagement, mission, campaign)
- O2.2 Identify prospective operational models from a list of models
- O2.3 Identify levels of detail typically included in operational analyses
- O2.4 Understand the role of aggregation and disaggregation across operational levels of detail
- O2.5 Understand the importance of developing quantifiable metrics of performance to meet mission requirements
- O2.6 Understand the difference in data requirements at different levels of abstraction
- O2.7 Describe the role of modeling inputs and assumptions in developing operational analysis (scenario & threat, missions, alternatives, required input data, operations concept, basing & deployment, support concept, [MAIS AoA: organizational missions, functions, & objective]).
- O2.8 Understand the importance of sensitivity analysis of critical assumptions in determine solution outputs.
- O2.9 Given a case study, assess the effectiveness of a sample suite of operational models in evaluating the full range of operational requirements (reliability, effectiveness, logistics footprint, supportability criteria, etc.) to sustain the

	O3) Know the properties of a representative suite of logistics models across the services.								
	O3.1	O3.2	O3.3	O3.4	O3.5	O3.6	O3.7	O3.8	O3.9
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	General Awareness	General Awareness	General Awareness	Understand	Understand	Understand	General Awareness	General Awareness	Mastery
Advanced	General Awareness	General Awareness	General Awareness	Understand	Understand	Understand	General Awareness	General Awareness	Mastery
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	General Awareness	General Awareness	General Awareness	Understand	Understand	Understand	General Awareness	General Awareness	Application
Advanced	General Awareness	General Awareness	General Awareness	Understand	Understand	Understand	General Awareness	General Awareness	Application
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	General Awareness	General Awareness	General Awareness	Understand	Understand	Understand	General Awareness	General Awareness	Mastery
Advanced	General Awareness	General Awareness	General Awareness	Understand	Understand	Understand	General Awareness	General Awareness	Mastery

- O3.1 Identify levels of detail typically included logistics analyses  
 O3.2 Identify prospective logistics models from a list of models  
 O3.3 Identify levels of detail typically included in logistics analyses  
 O3.4 Understand the role of aggregation across logistical levels of detail  
 O3.5 Understand the importance of developing quantifiable metrics of performance to meet mission requirements  
 O3.6 Understand the difference in data requirements at different levels of abstraction  
 Describe the role of modeling inputs and assumptions in developing operational analysis (scenario & threat, missions, alternatives, required input data, operations concept, basing & deployment, support concept, [MAIS AoA: organizational missions, functions, & objective]).  
 O3.7  
 O3.8 Understand the importance of sensitivity analysis of critical assumptions in determine solution outputs.  
 O3.9 Given a case study, assess the effectiveness of a sample suite of logistical models in evaluating the full range of logistical requirements (reliability, effectiveness, logistics footprint, supportability criteria, etc.) to sustain the

	O4) Select appropriate level of abstraction and fidelity for an operational and logistical model.							
	O4.1	O4.2	O4.3	O4.4	O4.5	O4.6	O4.7	O4.8
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	General Awareness	Understand	Understand	Understand	General Awareness	Understand	Mastery	Mastery
Advanced	General Awareness	Understand	Understand	Understand	General Awareness	Understand	Mastery	Mastery
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	General Awareness	Understand	Understand	Understand	General Awareness	Understand	Application	Application
Advanced	General Awareness	Understand	Understand	Understand	General Awareness	Understand	Application	Application
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	General Awareness	Understand	Understand	Understand	General Awareness	Understand	Mastery	Mastery
Advanced	General Awareness	Understand	Understand	Understand	General Awareness	Understand	Mastery	Mastery

- O4.1 Describe types of operational and logistics analyses (technical effectiveness, system effectiveness, system availability, operational availability, operational reliability, response time, workload allocation, and supply chain management) and the levels of detail typically included in these analyses
- O4.2 Understand the role of aggregation and disaggregation across operational and logistical levels of detail
- O4.3 Understand the quantifiable metrics available at varying levels of abstraction and realism
- O4.4 Understand the difference in data requirements at different levels of abstraction
- O4.5 Describe the role of modeling inputs and assumptions in developing an operational or logistics analysis (scenario & threat, missions, alternatives, required input data, operations concept, basing & deployment, support concept, [MAIS AoA: organizational missions, functions, & objective]).
- O4.6 Understand the importance of sensitivity analysis of critical assumptions in determine solution outputs.
- O4.7 Given a case study, assess how differences between levels of abstraction support different the different phases of the acquisition cycle
- O4.8 Given a case study, evaluate the impact of different levels of abstraction on verification and validation

	O5) Identify appropriate M&S applications for each of the components of logistics systems, including Supply Chain, Storage systems, Facilities, Production, Inventory management, Transportation & distribution, Replenishment policies										
	O5.1	O5.2	O5.3	O5.4	O5.5	O5.6	O5.7	O5.8	O5.9	O5.10	O5.11
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	General Awareness	General Awareness	Understand	Understand	Understand	Mastery	Mastery	Mastery	Mastery	Mastery	Mastery
Advanced	General Awareness	General Awareness	Understand	Understand	Understand	Mastery	Mastery	Mastery	Mastery	Mastery	Mastery
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	General Awareness	General Awareness	Understand	Understand	Understand	Application	Application	Application	Application	Application	Application
Advanced	General Awareness	General Awareness	Understand	Understand	Understand	Application	Application	Application	Application	Application	Application
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	General Awareness	General Awareness	Understand	Understand	Understand	Mastery	Mastery	Mastery	Mastery	Mastery	Mastery
Advanced	General Awareness	General Awareness	Understand	Understand	Understand	Mastery	Mastery	Mastery	Mastery	Mastery	Mastery

- O5.1 Identify the methods and characteristics of different supply chain, et al modeling methods (e.g., discrete event simulation, constraint optimization, spreadsheet, network design, rough cut methods, discrete vs. stochastic)
- O5.2 Describe the advantages/disadvantages to different methods of different supply chain, et al modeling methods (discrete event simulation, constraint optimization, and spreadsheet)
- O5.3 Understand the role of constraints and the methods for capturing them in various modeling methodologies
- O5.4 Understand the role of data in logistics modeling, the challenges in obtaining data, and the importance of sensitivity analysis of input data and of analysis drivers
- O5.5 Understand how to integrate end-to-end logistics system modeling from production and the start of the supply chain to distribution and the setting of replenishment policies
- O5.6 Given a case study, apply or analyze the methods used and the components considered in modeling a Supply Chain
- O5.7 Given a case study, apply or analyze the methods used and the components considered in modeling a Storage System
- O5.8 Given a case study, apply or analyze the methods used and the components considered in modeling a Production Facility
- O5.9 Given a case study, apply or analyze the methods used and the components considered in modeling Inventory Management
- O5.10 Given a case study, apply or analyze the methods used and the components considered in modeling a Distribution Network
- O5.11 Given a case study, apply or analyze the methods used and the components considered in modeling Replenishment Policies



	E1) Structural Mechanics, Shock and Vibrations Describe basic structural mechanics including stress-strain relations, buckling and fatigue, shock and vibration, and finite element methods in M&S.						
	E11.1	E11.2	E11.3	E11.4	E11.5	E11.6	E11.7
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	Understand	Understand	Understand	Understand	Understand	Understand	General Awareness
Advanced	Understand	Understand	Understand	Understand	Understand	Understand	General Awareness
Basic	Understand	Understand	Understand	Understand	Understand	Understand	General Awareness
Intermediate	Application	Understand	Understand	Understand	Understand	Application	Understand
Advanced	Application	Application	Application	Application	Application	Application	Understand
Basic	Understand	Understand	Understand	Understand	Understand	Understand	General Awareness
Intermediate	Application	Application	Application	Application	Application	Application	Understand
Advanced	Application	Application	Application	Application	Application	Application	Application

- E1.1 Governing equations of mass, momentum, and energy conservation  
 E1.2 Constitutive (stress-strain) theories and ranges of applicability  
 E1.3 Basic applications from strengths of materials (e.g. bar, beam under thermomechanical strain)  
 E1.4 Numerical solution techniques such as finite difference, Rayleigh-Ritz, and finite element  
 E1.5 Finite element method and application to structural mechanics  
 E1.6 Limitations of finite elements  
 E1.7 Other methods

	E2) Fluid Dynamics and Weapon System Describe the basics of computational fluid dynamics for CFD application and use for M&S. Fluid dynamics of subsonic and supersonic weapons, warheads and their effects.									
	E2.1	E2.2	E2.3	E2.4	E2.5	E2.6	E2.7	E2.8	E2.9	E2.10
Basic	Understand	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	Understand	Understand
Intermediate	Understand	Understand	General Awareness	Understand	Understand	Understand	Understand	Understand	Understand	Understand
Advanced	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand
Basic	Understand	General Awareness	General Awareness	General Awareness	Understand	Understand	Understand	General Awareness	Understand	Understand
Intermediate	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand
Advanced	Understand	Application	Understand	Application	Application	Application	Application	Understand	Application	Application
Basic	Understand	General Awareness	General Awareness	Understand	General Awareness	Understand	Understand	General Awareness	Understand	Understand
Intermediate	Understand	Understand	Understand	Application	Understand	Application	Application	Understand	Application	Application
Advanced	Understand	Application	Application	Application	Application	Application	Application	Application	Application	Application

- E2.1 Philosophy of CFD and its role in the triad of experimental, theoretical, and numerical approaches
- E2.2 Basic governing equations for fluid dynamics, including inviscid and viscous forms suitable for CFD
- E2.3 Classes and behavior of partial differential equations; finite difference and finite volume formulations; and stability and convergence
- E2.4 Grid generation and the primary types (structured, unstructured, overset, etc.)
- E2.5 Basic CFD techniques for incompressible and compressible flows
- E2.6 Solutions of the Euler, Boundary Layer, Parabolized Navier-Stokes, and full Navier-Stokes equations in the context of subsonic and supersonic weapon applications
- E2.7 Modeling of turbulent flows, unsteady flows, and high-temperature flows in the context of subsonic and supersonic weapon applications
- E2.8 Flow visualization and data analysis techniques
- E2.9 Validation and verification methodologies using experimental, theoretical, and numerical data
- E2.10 Future of CFD in research and engineering

	<b>E4) Thermodynamics and Heat Transfer</b> Describe the fundamentals of thermodynamics and heat transfer with applications to M&S in engineering power cycles, propulsion and auxiliary system cycle analysis and design.										
	E4.1	E4.2	E4.3	E4.4	E4.5	E4.6	4.7	4.8	E4.9	E4.10	E4.11
Basic	Understand	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand	General Awareness	General Awareness
Advanced	Application	Application	Understand	Understand	Understand	Understand	Understand	Understand	Understand	General Awareness	General Awareness
Basic	Understand	Understand	Understand	General Awareness	Understand	Understand	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	Application	Application	Application	Application	Application	Application	Application	Application	Application	Understand	Understand
Advanced	Application	Application	Understand	Application	Application	Application	Application	Understand	Application	Application	Understand
Basic	Application	Application	Understand	Understand	Understand	Understand	Understand	Understand	Understand	General Awareness	General Awareness
Intermediate	Application	Application	Application	Application	Understand	Application	Application	Understand	Understand	Understand	Understand
Advanced	Application	Application	Application	Application	Application	Application	Application	Application	Application	Application	Application

- E4.1 Governing equations of mass, momentum, energy conservation (1<sup>st</sup> Law and 2<sup>nd</sup> Law) and heat transfer (conduction, convection, and radiation)
- E4.2 Physical properties and constitutive relationships
- E4.3 Thermodynamic cycles
- E4.4 Combustion and chemical reactions
- E4.5 Power cycle applications: steam power cycle, refrigeration, heat pumps, turbines, rockets and jets, and internal combustion engines
- E4.6 Heat transfer applications: Aerodynamic heating, IR signature, satellite heating and cooling, engine cooling, electronics cooling, HVAC, solar heating, phase change
- E4.7 Numerical solution techniques such as finite difference, finite volume, and finite element
- E4.8 Application of finite element method to heat transfer problems
- E4.9 Limitations of finite elements
- E4.10 Chemical reaction and combustion numerical methods
- E4.11 Other simulation methods

	E5) Provide a basic introduction and review of materials science, including discussion of stress/strain definitions and relationship and the different classes/types of materials and their uses.								
	E5.1	E5.2	E5.3	E5.4	E5.5	E5.6	E5.7	E5.8	E5.9
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	General Awareness	Understand	Understand	Understand	Understand	General Awareness	General Awareness	General Awareness	General Awareness
Advanced	General Awareness	Understand	Understand	Understand	Understand	General Awareness	General Awareness	General Awareness	General Awareness
Basic	General Awareness	Understand	Understand	Understand	Understand	General Awareness	Understand	Understand	General Awareness
Intermediate	General Awareness	Understand	Understand	Understand	Understand	General Awareness	Understand	Understand	Understand
Advanced	General Awareness	Understand	Understand	Understand	Understand	Understand	Understand	Understand	Understand
Basic	General Awareness	Understand	Understand	Understand	Understand	General Awareness	Understand	Application	Understand
Intermediate	General Awareness	Understand	Understand	Understand	Understand	General Awareness	Application	Application	Understand
Advanced	General Awareness	Understand	Understand	Understand	Understand	Understand	Application	Application	Understand

- E5.2 Discuss the fundamental behavior of metals, their methods of manufacture and the effect of fabrication parameters and other factors (e.g., strain rate, temperature) on their final properties. Discussions to include heat treatment, strain hardening and corrosion.
- E5.3 Discuss the fundamental behavior of ceramics and glasses, their methods of manufacture and the effect of fabrication parameters and other factors on final properties.
- E5.4 Discuss the fundamental behavior of polymeric materials, their methods of manufacture and the effect of fabrication parameters and environmental factors on final properties.
- E5.5 Discuss the fundamental behavior of composite materials, their methods of manufacture and the effect of fabrication and other parameters on final properties.
- E5.6 Discuss the manufacture and behavior of novel materials such as superconductors, fiber optics, etc.
- E5.7 Provide a basic understanding of material joining techniques (i.e., welding, adhesive bonding, bolted joints) and methods of estimating/ measuring their impact on interfacial and overall properties.
- E5.8 Provide a general overview of testing methods for determining the various material properties used in M&S, including both quasi-static and dynamic/high-rate methods. Discussions will also be presented on detection and quantification of manufacturing and/or
- E5.9 Discuss general classes of material coatings and their applications, such as corrosion and wear prevention.

	E6: Acoustic and Electromagnetic Systems - Describe the fundamentals of acoustic and electromagnetic wave propagation in M&S applications.					
	E6.1	E6.2	E6.3	E6.4	E6.5	E6.6
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Advanced	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Basic	Understand	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	Understand	Understand	Application	Application	Application	Application
Advanced	Understand	Understand	Mastery	Mastery	Mastery	Mastery
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	General Awareness	General Awareness	Understand	Understand	Understand	Understand
Advanced	General Awareness	General Awareness	Understand	Understand	Understand	Understand

- E6.1 Demonstrate competency to the level specified in E6 applied to acoustic wave propagation
- E6.2 Demonstrate competency to the level specified in E6 applied to electromagnetic wave propagation
- E6.3 Demonstrate competency to the level specified in E6 applied to acoustic communication systems
- E6.4 Demonstrate competency to the level specified in E6 applied to electromagnetic communication systems
- E6.5 Demonstrate competency to the level specified in E6 applied to acoustic active and passive detection systems
- E6.6 Demonstrate competency to the level specified in E6 applied to acoustic active and passive detection systems

	E7) Military Platform Systems Engineering - Apply a broad-based design oriented M&S approach for complex platforms that interact with air-land-sea-based hardware systems, command and control systems and combat systems.									
	E7.1	E7.2	E7.3	E7.4	E7.5	E7.6	E7.7	E7.8	E7.9	E7.10
Basic	General Awareness	General Awareness	General Awareness	Application	Application	General Awareness	Application	Understand	Understand	Understand
Intermediate	General Awareness	Understand	Understand	Mastery	Mastery	Understand	Mastery	Mastery	Mastery	Mastery
Advanced	General Awareness	Understand	Understand	Application	Application	Understand	Application	Understand	Understand	Understand
Basic	General Awareness	General Awareness	General Awareness	Application	Application	General Awareness	Application	Understand	Understand	Understand
Intermediate	General Awareness	Understand	Understand	Mastery	Mastery	Understand	Mastery	Mastery	Mastery	Mastery
Advanced	General Awareness	Understand	Understand	Mastery	Mastery	Understand	Mastery	Mastery	Mastery	Mastery
Basic	General Awareness	General Awareness	General Awareness	Application	Application	General Awareness	Application	Understand	Understand	Understand
Intermediate	General Awareness	Understand	Understand	Mastery	Mastery	Understand	Mastery	Mastery	Mastery	Mastery
Advanced	General Awareness	Understand	Understand	Mastery	Mastery	Understand	Mastery	Mastery	Mastery	Mastery

- E7.1 Identify key fundamental theoretical principles in systems engineering
- E7.2 Describe the role and benefits of M&S in systems engineering
- E7.3 Given a case study, understand key system characteristics of the system and component subsystems of interest
- E7.4 Given a case study, identify the key elements of the system and component subsystem to be modeled to meet the requirements of the specific use
- E7.5 Given a case study, apply or analyze the effectiveness of simulation tools used to evaluate the performance of the system and components subsystems
- E7.6 Describe the role of component-based and distributed simulation as it applies to the system and component subsystems
- E7.7 Given a case study, apply or analyze key M&S issues related to interaction of subsystems within a larger system
- E7.8 Given a case study, analyze the VV&A implication of using a simulation of a system that is sufficiently different from its intended use
- E7.9 Given a case study, analyze whether the system and component subsystems are modeled in sufficient detail to support program milestone decision requirements
- E7.10 Given a case study, analyze whether the system and component subsystems are modeled in sufficient detail to support T&E requirements

	E8) Computers- Describe the basic computer system architecture, operating systems, networking and introduction to engineering software and their applications. Classify structured programming languages such as Fortran and C, and the use of such tools for code development. Recognize finite element/difference codes, with application to solve engineering problems including experience with selected software packages.						
	E8.1	E8.2	E8.3	E8.4	E8.5	E8.6	E8.7
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	Understand	Application	Application	Application	Application	Application	Application
Advanced	Application	Application	Application	Application	Application	Application	Mastery
Basic	Understand	Understand	Understand	Understand	Understand	Understand	Understand
Intermediate	Application	Application	Application	Application	Application	Application	Application
Advanced	Application	Mastery	Mastery	Mastery	Mastery	Mastery	Application
Basic	General Awareness	Understand	Understand	Understand	Understand	Understand	General Awareness
Intermediate	Understand	Application	Application	Application	Application	Application	Understand
Advanced	Understand	Mastery	Mastery	Mastery	Mastery	Mastery	Understand

E8.1 Demonstrate competency to the level specified in matrix on *basic computer system architecture*, operating systems, networking, introductory engineering software and their application to Modeling and Simulation (M&S) applications, introductory *structured programming languages* such as Fortran and C, and the use of such languages for *software development*.

E8.2 Demonstrate competency to the level specified in matrix on the use of selected *Runtime software systems* to build *M&S scenarios* to support PMs, SEs, and T&E requirements across the system life cycle.  
[Case Study: Presagis Vega and AIS SVS]

E8.3 Demonstrate competency to the level specified in matrix on the use of selected *Intelligent Agent software systems* to build *M&S scenarios* to support PMs, SEs, and T&E requirements across the system life cycle.  
[Case Study: PEO-STRI OneSAF Objective System, Mak VR Forces with B-HAVE module, and SimBionic ]

E8.4 Demonstrate competency to the level specified in matrix on using M&S, interoperability, and intelligent agent software tools to build massively *online systems* so as to support T&E with such software systems.

E8.5 Demonstrate competency to the level specified in matrix on how Live training M&S is used to *support training and testing requirements*.  
[Case Study: Live simulation programs such as the PEO STRI OneTESS (One Tactical Engagement Simulation System) program is used to support key functional/technological areas such as geometric pairing, communications modeling, weapon/ballistic simulations]

E8.6 Demonstrate competency to the level specified in matrix on how *SMART framework/tools* are used specifically in *exploiting virtual training M&S* to benefit both acquisition and training throughout the system life cycle from the PM/SE/T&E perspectives.  
[Case Study: PEO-STRI training simulations such as Close Combat Tactical Training System]

E8.7 Demonstrate competency to the level specified in matrix on the use of *Computer Assisted System Engineering* tools to support project life cycle development/engineering.

	E9: Electrical Engineering - Describe basic circuit analysis including DC and AC circuits. Describe the construction and operating characteristics of rotating machinery, static converters, power distribution systems and multi-phased circuits.			
	E9.1	E9.2	E9.3	E9.4
Basic	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	General Awareness	General Awareness	General Awareness	General Awareness
Advanced	General Awareness	General Awareness	Understand	Understand
Basic	Understand	Understand	Understand	Understand
Intermediate	Understand	Understand	Application	Application
Advanced	Understand	Application	Mastery	Mastery
Basic	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	Understand	Understand	Understand	Understand
Advanced	Understand	Understand	Application	Application

- E9.1 Demonstrate competency to the level specified in E9 for M&S tools applied to the design and analysis of basic AC and DC circuits
- E9.2 Demonstrate competency to the level specified in E9 for M&S tools applied to AC and DC motors and power distribution
- E9.3 Demonstrate competency to the level specified in E9 for M&S tools that are used to perform system trade-off's between AC and DC motors and power distribution systems
- E9.4 Demonstrate competency to the level specified in E9 for M&S tools used to evaluate military AC and DC motors and power distribution systems



	E10) C4ISR - Describe the basic components, methods and alternatives for transferring information from one point to another both internal and external to the system being considered. Evaluate available technologies for achieving rapid/effective/jam-resistant information transfer.								
	E10.1	E10.2	E10.3	E10.4	E10.5	E10.6	E10.7	E10.8	E10.9
Basic	General Awareness	General Awareness	General Awareness	Application	Application	Application	Understand	Understand	Understand
Intermediate	General Awareness	Understand	Understand	Mastery	Mastery	Mastery	Mastery	Mastery	Mastery
Advanced	General Awareness	Understand	Understand	Application	Application	Application	Understand	Understand	Understand
Basic	General Awareness	General Awareness	General Awareness	Application	Application	Application	Understand	Understand	Understand
Intermediate	General Awareness	Understand	Understand	Mastery	Mastery	Mastery	Mastery	Mastery	Mastery
Advanced	General Awareness	Understand	Understand	Mastery	Mastery	Mastery	Mastery	Mastery	Mastery
Basic	General Awareness	General Awareness	General Awareness	Application	Application	Application	Understand	Understand	Understand
Intermediate	General Awareness	Understand	Understand	Mastery	Mastery	Mastery	Mastery	Mastery	Mastery
Advanced	General Awareness	Understand	Understand	Mastery	Mastery	Mastery	Mastery	Mastery	Mastery

E10.1 Identify key fundamental theoretical principles in C4ISR systems engineering

E10.2 Describe the role and benefits of M&S in C4ISR systems engineering

E10.3 Given a case study, understand key system characteristics of the C4ISR system of interest

E10.4 Given a case study, identify the key elements of the C4ISR system to be modeled to meet the requirements of the specific use

E10.5 Given a case study, apply or analyze the effectiveness of simulation tools used to evaluate the performance of the C4ISR system

E10.6 Given a case study, apply or analyze key M&S issues related to interaction of subsystems within the C4ISR systems

E10.7 Given a case study, analyze the VV&A implications of using a simulation of a C4ISR system given that is sufficiently different from its intended use

E10.8 Given a case study, analyze whether the C4ISR system is modeled in sufficient detail to support program milestone decision requirements

E10.9 Given a case study, analyze whether the C4ISR system is modeled in sufficient detail to support T&E requirements

	<b>E11) Networks</b> Describe the principles of networks applied to military applications including physical, command and control, and social networks and their implications for engineering design of systems.						
	<b>E11.1</b>	<b>E11.2</b>	<b>E11.3</b>	<b>E11.4</b>	<b>E11.5</b>	<b>E11.6</b>	<b>E11.7</b>
Basic	General Awareness	Understand	Understand				
Intermediate	General Awareness	Understand	Understand	Understand	Understand	Understand	Understand
Advanced	General Awareness	Understand	Understand	Understand	Understand	Understand	Understand
Basic	General Awareness	Understand	Understand				
Intermediate	Understand	Application	Application	Application	Application	Application	Application
Advanced	Understand	Application	Application	Application	Application	Application	Application
Basic	General Awareness	Understand	Understand	Understand	Understand	Understand	Understand
Intermediate	Understand	Understand	Understand	Understand	Understand	Understand	Understand
Advanced	Understand	Application	Application	Application	Application	Application	Application

- E11.1 Provide a basic introduction of communications networks, including data and voice communications and military applications of networks.
- E11.2 Provide an introduction of the uses of M&S for campaign and mission level analysis for the use of communications networks that facilitate data and voice communications (Prerequisite: E11.1 or appropriate knowledge)
- E11.3 Analyze force structure and mission requirements to set up models. Establish network parameters, topology requirements and information exchanges.
- E11.4 Provide intermediate-level instruction on network topology and protocols. (Prerequisite: E11.2 or appropriate knowledge)
- E11.5 Provide intermediate-level instruction to design of M&S applications and tools to simulate communications applications and networks. (Prerequisite: E11.4 or appropriate knowledge)
- E11.6 Provide detailed instruction on the uses of M&S for communications networks including hardware in the loop simulations at the link and physical layers. (Prerequisite: E11.5 or appropriate knowledge)
- E11.7 Provide detailed instruction to the uses of M&S to assess application and transport layer communications protocols including broadcast and specific addressed messages. (Prerequisite: E11.5 or appropriate knowledge)

	E12) Environment – Describe the fundamentals of terrestrial science (geology, oceanography, meteorology, and near-earth space science) to represent how systems interact with and are influenced by their environment.							
	E12.1	E12.2	E12.3	E12.4	E12.5	E12.6	E12.7	E12.8
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	Understand	Understand	General Awareness	Understand	Understand	Understand	Mastery	Understand
Advanced	Understand	Understand	General Awareness	Understand	Understand	Understand	Mastery	Understand
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	Understand	Understand	General Awareness	Application	Application	Mastery	Understand	Understand
Advanced	Understand	Understand	General Awareness	Application	Application	Mastery	Understand	Understand
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	Understand	Understand	General Awareness	Mastery	Mastery	Mastery	Understand	Mastery
Advanced	Understand	Understand	General Awareness	Mastery	Mastery	Mastery	Understand	Mastery

Given a case study, understand key fundamental theoretical principles in terrestrial science as they apply to the system of interest

E12.2 Given a case study, understand key system characteristics of the system of interest

E12.3 Given a case study, identify the key elements of the environment to be modeled to meet the requirements of the specific use  
Given a case study, apply or analyze the effectiveness of simulation tools used evaluate the performance of the system of interest

E12.4 interest in the environment

Given a case study, apply or analyze key M&S issues related to interaction of the system of interest with the environment

E12.5 (terrain database compatibility, line-of -sight, weather)

Given a case study, analyze the VV&A implications of using a simulation in an environment that is sufficiently different from it's intended use

E12.6 intended use

Given a case study, analyze if the environmental factors are modeled in sufficient detail to support program milestone decision

E12.7 requirements

E12.8 Given a case study, analyze if the environmental factors are modeled in sufficient detail to support T&E requirements

	E13) Human Systems Integration Describe the principles of Human Systems Integration. Describe the applications of M&S to support HSI design and analysis.						
	E13.1	E13.2	E13.3	E13.4	E13.5	E13.6	E13.7
Basic	General Awareness	Understand	Understand	Understand	Understand	Understand	General Awareness
Intermediate	Understand	Application	Application	Application	Application	Application	Understand
Advanced	Application	Mastery	Application	Mastery	Mastery	Application	Application
Basic	General Awareness	Understand	Understand	Understand	Understand	Understand	General Awareness
Intermediate	Understand	Understand	Application	Application	Application	Application	Understand
Advanced	Application	Understand	Application	Mastery	Mastery	Mastery	Application
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	Application
Intermediate	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness	Application
Advanced	Understand	Understand	Understand	Understand	Understand	Understand	Understand

E13.1 Define Human Systems Integration (HSI).

E13.2 Read HSI requirements outlined in DODI 5000.2.

E13.3 Describe the role of M&S in meeting HSI requirements.

E13.4 Describe how the modeling of HSI can improve system performance.

E13.5 Describe how the modeling of HSI can reduce system life cycle costs.

E13.6 Describe the potential benefits from HSI M&S on the system user population.

E13.7 List and describe existing M&S tools that are specifically structured to support HSI M&S.

	E13: Human Systems Integration – Describe the principles of Human Systems Integration. Describe the applications of M&S to support HSI design and analysis.				
	E13.1	E13.2	E13.3	E13.4	E13.5
Basic	General Awareness	General Awareness	General Awareness	General Awareness	General Awareness
Intermediate	General Awareness	General Awareness	General Awareness	General Awareness	Application
Advanced	General Awareness	General Awareness	General Awareness	Understand	Mastery
Basic	General Awareness	General Awareness	General Awareness	Understand	General Awareness
Intermediate	Understand	Understand	Understand	Application	Application
Advanced	Understand	Mastery	Mastery	Mastery	Application
Basic	Understand	Understand	Understand	Understand	General Awareness
Intermediate	Understand	Understand	Understand	Understand	General Awareness
Advanced	Understand	Understand	Understand	Application	General Awareness

- E13.1 Demonstrate competency to the level specified in E13 for M&S tools applied to Human System Integration and Human System Engineering HSI/HSE.
- E13.2 Demonstrate competency to the level specified in E13 for M&S tools applied to Human System Ergonomics
- E13.3 Demonstrate competency to the level specified in E13 for M&S tools applied to HSI audio and visual design
- E13.4 Demonstrate competency to the level specified in E13 for M&S tools applied to effective system operability.
- E13.5 Demonstrate competency to the level specified in E13 for M&S tools applied to HSI related to LCC and the acquisition process.

	<b>E14) Aerodynamics</b> Describe the principles of aerodynamics with applications to M&S. Describe the cost, schedule, and iterative development nature of simulation testbeds used for flight software development through formal qualification.								
	E14.1	E14.2	E14.3	E14.4	E14.5	E14.6	E14.7	E14.8	E14.9
Basic	General Awareness	General Awareness	General Awareness	General Awareness	Understand	Understand	Understand	Understand	Application
Intermediate	Understand	Understand	General Awareness	General Awareness	Application	Application	Application	Application	Mastery
Advanced	Understand	Understand	General Awareness	General Awareness	Application	Application	Application	Application	Mastery
Basic	General Awareness	General Awareness	General Awareness	General Awareness	Understand	Understand	Application	Application	Application
Intermediate	Understand	Understand	Understand	Understand	Application	Application	Mastery	Application	Mastery
Advanced	Understand	Understand	Understand	Understand	Application	Mastery	Mastery	Mastery	Mastery
Basic	General Awareness	Understand	Application	Application	Understand	General Awareness	General Awareness	Application	General Awareness
Intermediate	Understand	Application	Mastery	Application	Application	General Awareness	Understand	Mastery	Understand
Advanced	Understand	Application	Mastery	Application	Application	General Awareness	Understand	Mastery	Understand

E14.1 Describe the use of flight software for the control of aerodynamic surfaces on flight systems.

E14.2 Describe the fundamentals of controls logic and its relationship to aerodynamics.

E14.3 Explain aerodynamic scaling principles and their use in modeling and testing.

E14.4 Explain the fundamentals of computational fluid dynamics (CFD) and the related strengths, limitations and computational requirements in supporting M&S.

E14.5 Describe the iterative development of flight software and the associated roll of M&S.

E14.6 Describe the use of aerodynamic M&S in trade studies early in the system development cycle.

E14.7 Describe the use of aerodynamic M&S in system design optimization.

E14.8 Describe the use of aerodynamic M&S to support flight testing.

E14.9 Describe the iterative validation of aerodynamic simulation testbeds from ground and flight tests and the associated use of validated simulations to reduce testing costs and shorten development cycles for flight software formal qualification.

## 2.2 Learning Architecture

The second spiral activities were focused on the development of the learning architecture. The learning architecture is a framework for course development based on the requirements provided by the learning matrix from spiral one.

The architecture was developed in two phases – module syllabi development and course syllabi development. For each individual ESR, module syllabi were developed that outline the course material necessary to cover the ESR to the highest levels of competency required by the learning matrix. This resulted in a complete group of syllabi covering the material for the entire ESR set. The standardized outline for the module syllabi is presented in Figure 2.2.1. The complete set of module syllabi is presented in section 2.3.

- Standard Syllabus format for **Modules** that support the M&S project:
- 1) Module name
  - 2) Module coordinator / point of contact and contact information
  - 3) Module description (short description)
  - 4) ESRs that the module supports and the corresponding level of mastery.
  - 5) Prerequisites assumed, and corresponding level of mastery. If the prerequisites map to ESRs, please identify them.
  - 6) Module maturity: has it been taught, and if so, a brief history
  - 7) Number of hours estimated to deliver/teach module
  - 8) Proposed Delivery modality (face-to-face, on-line, VTC, resident, customer's site, etc.)
  - 9) Proposed references and texts
  - 10) Module learning objectives (and, again, where appropriate their mapping to the project ESRs identified in (4)).
  - 11) Course assessment plan (projects, exams, papers, etc.)
  - 12) Topic list by hour of instruction and reference. For example:
    - i) Hour one: Introduction and overview (course notes and syllabus)
    - ii) Hour two: Systems, Models, and Simulation (Law and Kelton, 1.1-1.3 )
    - iii) Etc.....

Figure 2.2.1 Module Syllabi Outline

Once the module syllabi were completed, logical aggregations of the materials then began to be compiled into course syllabi. The course syllabi follow the same outline as the module syllabi, with additional information indicating which module syllabi were incorporated, if applicable.

The resulting architecture provides a complete modular framework that can be tailored to the development of specific programs for various workforce members. The syllabi are presented in such a way that enables the user to extract the information required to achieve each desired level of competence for any ESR. For this program, a subset of the

course syllabi will be developed into full courses in the second year of the project. These courses are further described in section 2.4.



## 2.3 Module Syllabi

As described previously, module syllabi were developed for each individual ESR identified in the learning matrix. The intent of the module syllabi is to capture the requirements for providing education on each of the detailed ESRs to the various levels of competency. Each academic partner approached this problem differently, and their resulting syllabi vary in several ways. Our only stipulation was that we should be able to extract any subset of the material so that we could mix and match appropriate selections depending on the needs of the target audience.

One example of the variety is in the number of module syllabi proposed. For example, the UAH submission included separate syllabi for each level of competence required. This resulted in four syllabi for each ESR. However, most of the partners submitted one syllabus for each ESR, with distinctive markings indicating which portions of the syllabus which applied to each level of competence. In both cases, the end goal was achieved, and we were satisfied with the formats.

In some cases, we assigned multiple schools to a single ESR. There were a few reasons for doing this. It was a worthwhile exercise to see how different the resulting syllabi would be, and in many cases resulted in a better combined product. In some cases, the ESRs were especially challenging, and in some situations recognized technical expertise resided and more than one institution. Therefore, it was deemed appropriate to attempt to incorporate as much attention on those particular requirements as we could afford.

These module syllabi cover the complete spectrum of the ESRs identified by the stakeholders. While the final educational program developed through this project's funding will not provide the course materials for each of these syllabi, they are still valuable for reuse in the future. These syllabi can be used as design tools for programs or courses to be developed to satisfy educational needs of future programs if desired.

**P1) Describe the role of modeling and simulation prior to the concept decision to identify and quantify capability gaps and to estimate how well new program concepts might address those gaps.**

- 1) Title: M&S and the Joint Capabilities Integration and Development System (JCIDS) Analysis
- 2) Module coordinator / point of contact and contact information  
Jim Campbell, GMU, [jcampbell@alionscience.com](mailto:jcampbell@alionscience.com), 703-933-3356
- 3) Module description (short description): At the completion of this module, students will be able to describe the JCIDS process and how modeling and simulation is applied in functional analyses, and apply this information to new concept development. Taught to the Understanding Level; for courses at the general awareness level, time can be reduced and the practical application period deleted.
- 4) ESR supported: P1—Describe the role of modeling and simulation prior to the concept decision to identify and quantify capability gaps and to estimate how well new program concepts might address those gaps.
- 5) Prerequisites: ACQ 101, ACQ 201.
- 6) Module maturity: has it been taught, and if so, a brief history  
An over view of the JCIDS is taught in the Modeling and Simulation Staff Officer's Course and the GMU CPE course, but the material is at the general awareness level, or understanding level.
- 7) Number of hours Six.
- 8) Proposed Delivery modality face-to-face, or VTC; resident, or customer's site
- 9) Proposed references and texts:
  - a) CJCSI 3170.01F, Joint Capabilities Integration and Development System, 1 May 2007
  - b) CJCSM 3170.01C, Operation of the Joint Capabilities Integration and Development system, 1 May 2007
  - c) Defense Acquisition Guidebook, Version 1.0, 17 October 2004
- 10) Module learning objectives:
  - P1.1: Describe the JCIDS process prior to the Concept Decision.
  - P1.2: Identify the three types of Functional Analyses.

P1.3: Describe how M&S is used in each level of Functional Analysis.

P1.4: Identify the components of DOTMLPF.

P1.5: Describe how M&S is used for DOTMLPF determinations.

11) Course assessment plan: Examination and practical exercise.

12) Topic list by hour of instruction and reference:

- i) Hour one: Introduction and overview (CJCSI 3170.01F) P1.1
- ii) Hour two: Functional Analyses I (course notes and syllabus) P1.2, P1.3
- iii) Hour three: Functional Analyses II (course notes and syllabus) P1.2, P1.3
- iv) Hour four: DOTMLPF considerations (course notes and syllabus) P1.4, P1.5
- v) Hour five: Practical application (course notes and syllabus) P1 all
- vi) Hour six: Evaluation and Summary (course notes and syllabus) P1 all

13) Additional Requirements: N/A

**P2) Assess the costs, benefits, and risks of using physical testing, modeling and simulation, and historical data to provide information for acquisition decisions.**

- 1) Title: Impacts of M&S and Physical Testing on Acquisition Decisions
- 2) Module coordinator / point of contact and contact information:  
Jim Campbell, GMU, [jcampbell@alionscience.com](mailto:jcampbell@alionscience.com), 703-933-3356
- 3) Module description (short description) At the completion of this module, students will be able to apply example cases of M&S tools applications in a comparison and contrast of M&S capabilities to support cost, benefit, and risk analysis for test and evaluation with live test and historical data analysis. Taught to the Application Level; for courses at the understanding or general awareness level, time can be reduced and practical application period deleted.
- 4) ESR supported: P2— Assess the costs, benefits, and risks of using physical testing, modeling and simulation, and historical data to provide information for acquisition decisions.
- 5) Prerequisites: ACQ 101, ACQ 201, ESR P9.

Module maturity: N/A

- 6) Number of hours Six.
- 7) Proposed Delivery modality face-to-face, or VTC; resident, or customer's site
- 8) Proposed references and texts:
  - a) DoD Directive 5000.1, Defense Acquisition System, 12 May 2003
  - b) DoD Instruction 5000.2, Operation of the Defense Acquisition System, 12 May 2003
  - c) DoD Directive 5000.59, DoD Modeling and Simulation (M&S) Management, 8 August 2007
  - d) Defense Acquisition Guidebook, Version 1.0, 17 October 2004
  - e) AR 73-1, Test and Evaluation Policy, 1 August 2006
  - f) SECNAVINST 5000.2C, Implementation and Operation of the Defense Acquisition System and the Joint Capabilities Integration and Development System, 19 November 2004

g) AFI 99-103, Capabilities Based Test and Evaluation, 6 August 2004

9) Module learning objectives:

P2. 1: Describe the cost of physical testing vis a vis modeling and simulation, and historical data analysis

P2. 2: Describe the benefits of physical testing vis a vis modeling and simulation, and historical data analysis

P2. 3: Describe the risks of physical testing vis a vis modeling and simulation, and historical data analysis

P2. 4: Describe how physical test, M&S and historical data can be combined to provide effective decision support

10) Course assessment plan Examination and practical exercise.

11) Topic list by hour of instruction and reference:

i) Hour one: Overview of M&S (course notes and syllabus) P2.4

ii) Hour two: Cost considerations (course notes and syllabus) P2.1

iii) Hour three: Benefits (course notes and syllabus) P2.2

iv) Hour four: Risk considerations (course notes and syllabus) P2.3

v) Hour five: Practical application (course notes and syllabus) P2 all

vi) Hour six: Examination and summary (course notes and syllabus) P2 all

13) Additional Requirements: N/A

**P3) Know the technical aspects of the domain of application.**

We acknowledge the importance of possessing an understanding of a particular field in order to effectively apply M&S within. However, we decided that it is not within the scope of the project to teach this for all domains and therefore did not decompose this ESR to further detail.

**P4) Know the taxonomy and hierarchies of models and simulations and be able to select appropriately for a given situation. Understand the types of architectures and role of architectures in tying together and communicating requirements, analysis, modeling and simulation, design, and development planning to all stakeholders. Apply M&S in different testing environments (Live, Virtual, and Constructive). Apply both standalone and interoperable simulations in appropriate situations. Select among different simulation interoperability standards when necessary.**

1) Module name P4-G M&S environments and interoperability (General awareness)

2) Coordinator

Dr. Mikel D. Petty, UAH CMSA, 256-824-4368, pettym@uah.edu

3) Module description This module comprises topics to provide training to a “General awareness” level of competence for program managers, systems engineers, and test and evaluation workforce members for ESR P4: Apply M&S in different testing environments (Live, Virtual, and Constructive). Apply both standalone and interoperable simulations in appropriate situations. Select among different simulation interoperability standards when necessary.

4) ESRs that the module supports and the corresponding level of competence

P4 General awareness.

5) Prerequisites assumed and the corresponding level of competence Basic familiarity with M&S concepts, equivalent to MSIAC M&S Staff Officers Course.

6) Module maturity Portions of the material have been taught by the module coordinator in both Old Dominion University’s MSIM 601 course and in Certified Modeling and Simulation Professional examination preparation courses.

7) Number of hours estimated to deliver/teach module 8

8) Proposed delivery modalities Face-to-face lecture, synchronous distance learning (live audio/video connection), asynchronous distance learning (web or CD).

9) Proposed references and texts (topics refer to these by number)

[1] R. M. Fujimoto, “Distributed Simulation and the High Level Architecture”, in W. B. Rouse and K. R. Boff (Editors), *Organizational Simulation*, John Wiley & Sons, Hoboken NJ, 2005, pp. 591-609.

[2] R. M. Fujimoto, “Parallel and Distributed Simulation”, in J. Banks (Editor), *Handbook of Simulation*, John Wiley & Sons, New York 1998, pp. 429-464.

[3] M. Petty, MSIM 601 and CMSP Exam Prep lecture notes.

[4] O. Balci, “Verification, Validation, and Testing”, in J. Banks (Editor), *Handbook of Simulation*, John Wiley & Sons, New York 1998, pp. 335-393.

- 10) Module learning objectives Correspond to sub-ESRs for ESR P4.
- a) P4.1 Define the different testing environments (live, virtual, and constructive) and compare the relative advantages and disadvantages of each environment for different product and system testing applications.
  - b) P4.2 Identify the attributes of an M&S application that determine whether a live, virtual, constructive, or combination environment would be most appropriate, and the values for those attributes that indicate each type.
  - c) P4.3 List significant and widely used models, standalone simulations, confederated simulations, data sets, and interoperability protocol standards applied in the different environments.
  - d) P4.4 Describe approaches to testing and validating models and simulations suitable for use in each of the environments, and identify degree of accuracy typically required in that environment.
  - e) P4.5 Define the differences between standalone and federated simulation and give examples of each that have been used successfully in test and acquisition applications. Identify the attributes of an M&S application that determine whether a standalone simulation or a federation of interoperable simulations would be more appropriate, and the values for those attributes that indicate each type.
  - f) P4.6 List current simulation interoperability protocol standards and describe the advantages and disadvantages of each in each of the different environments.
  - g) P4.7 List existing resources in each of the environments, including model repositories, implemented federations of interoperable simulations, standalone simulations, standard object models, and accredited data sets, and describe the procedures for searching for resources within repositories of them.
  - h) P4.8 Describe case studies of successful test and acquisition M&S applications in each of the different environments.

11) Course assessment plan End of module examination

12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)

- 1. Basic concepts, definitions, and examples of live, virtual, and constructive environments; P4.1; [1] [2] [3]
- 2. Basic concepts, definitions, and examples of M&S application attributes; P4.2; [4]
- 3. Basic concepts, definitions, and examples of categories (models, standalone simulations, interoperable simulations, data sets, and interoperability protocol standards) within live, virtual, and constructive environments; P4.3; ; [1] [2] [3]
- 4. Basic concepts, definitions, and examples of testing and validation in live, virtual, and constructive environments; P4.4; [4]
- 5. Basic concepts, definitions, and examples of standalone and interoperable simulations; P4.5; ; [1] [2] [3]
- 6. Basic concepts, definitions, and examples of interoperability protocol standards; P4.6; [1] [2] [3]
- 7. Basic concepts, definitions, and examples of each type of existing resource in live, virtual, and constructive environments; P4.7; to be determined



8. Simple case studies of successful test and acquisition M&S applications; P4.8; to be determined
- 

1) Module name P4-U M&S environments and interoperability (Understanding)

2) Coordinator

Dr. Mikel D. Petty, UAH CMSA, 256-824-4368, pettym@uah.edu

3) Module description This module comprises topics to provide training to a “Understanding” level of competence for program managers, systems engineers, and test and evaluation workforce members for ESR P4: Apply M&S in different testing environments (Live, Virtual, and Constructive). Apply both standalone and interoperable simulations in appropriate situations. Select among different simulation interoperability standards when necessary.

4) ESRs that the module supports and the corresponding level of competence  
P4 Understanding

5) Prerequisites assumed and the corresponding level of competence Module P4-G

6) Module maturity Portions of the material have been taught by the module coordinator in both Old Dominion University’s MSIM 601 course and in Certified Modeling and Simulation Professional examination preparation courses.

7) Number of hours estimated to deliver/teach module 12

8) Proposed delivery modalities Face-to-face lecture, synchronous distance learning (live audio/video connection), asynchronous distance learning (web or CD)

9) Proposed references and texts (topics refer to these by number)

[1] R. M. Fujimoto, “Distributed Simulation and the High Level Architecture”, in W. B. Rouse and K. R. Boff (Editors), *Organizational Simulation*, John Wiley & Sons, Hoboken NJ, 2005, pp. 591-609.

[2] R. M. Fujimoto, “Parallel and Distributed Simulation”, in J. Banks (Editor), *Handbook of Simulation*, John Wiley & Sons, New York 1998, pp. 429-464.

[3] M. Petty, MSIM 601 and CMSP Exam Prep lecture notes.

[4] O. Balci, “Verification, Validation, and Testing”, in J. Banks (Editor), *Handbook of Simulation*, John Wiley & Sons, New York 1998, pp. 335-393.

10) Module learning objectives Correspond to sub-ESRs for ESR P4

- a) P4.1 Define the different testing environments (live, virtual, and constructive) and compare the relative advantages and disadvantages of each environment for different product and system testing applications.

- b) P4.2 Identify the attributes of an M&S application that determine whether a live, virtual, constructive, or combination environment would be most appropriate, and the values for those attributes that indicate each type.
- c) P4.3 List significant and widely used models, standalone simulations, confederated simulations, data sets, and interoperability protocol standards applied in the different environments.
- d) P4.4 Describe approaches to testing and validating models and simulations suitable for use in each of the environments, and identify degree of accuracy typically required in that environment.
- e) P4.5 Define the differences between standalone and federated simulation and give examples of each that have been used successfully in test and acquisition applications. Identify the attributes of an M&S application that determine whether a standalone simulation or a federation of interoperable simulations would be more appropriate, and the values for those attributes that indicate each type.
- f) P4.6 List current simulation interoperability protocol standards and describe the advantages and disadvantages of each in each of the different environments.
- g) P4.7 List existing resources in each of the environments, including model repositories, implemented federations of interoperable simulations, standalone simulations, standard object models, and accredited data sets, and describe the procedures for searching for resources within repositories of them.
- h) P4.8 Describe case studies of successful test and acquisition M&S applications in each of the different environments.

11) Course assessment plan End of module examination

12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)

1. Typical product and system testing applications and advantages and disadvantages of live, virtual, and constructive environments for each; P4.1; [3]
2. Typical live, virtual, and constructive environment architectures; P4.1; [3]
3. Attributes of M&S applications typically found in live, virtual, and constructive environments; P4.2; [3]
4. Lists of significant and widely used items in each category and explanations for their significance live, virtual, and constructive environments; P4.3; to be determined
5. Details of different testing and validation methods used in live, virtual, and constructive environments; P4.4; [4]
6. Differences and advantages/disadvantages of standalone and interoperable simulations; P4.5; [1] [2] [3] [4]
7. Examples of successful use of standalone and interoperable simulations for test and acquisition applications; P4.5; to be determined
8. Technical details of current interoperability protocol standards; P4.6; [1] [2] [3]
9. Relative capabilities and typical applications of current interoperability protocol standards in live, virtual, and constructive environments; P4.6; [1] [2] [3]
10. Lists and details of existing resources in live, virtual, and constructive environments; P4.7; to be determined

11. Resource repositories in live, virtual, and constructive environments; P4.7; to be determined
12. Advanced case studies of both successful and unsuccessful test and acquisition M&S applications; P4.8; to be determined

- 
- 1) Module name P4-A M&S environments and interoperability (Application)
  - 2) Coordinator  
Dr. Mikel D. Petty, UAH CMSA, 256-824-4368, pettym@uah.edu
  - 3) Module description This module comprises topics to provide training to a “Application” level of competence for program managers, systems engineers, and test and evaluation workforce members for ESR P4: Apply M&S in different testing environments (Live, Virtual, and Constructive). Apply both standalone and interoperable simulations in appropriate situations. Select among different simulation interoperability standards when necessary.
  - 4) ESRs that the module supports and the corresponding level of competence  
P4 Application.
  - 5) Prerequisites assumed and the corresponding level of competence Module P4-U
  - 6) Module maturity Portions of the material have been taught by the module coordinator in both Old Dominion University’s MSIM 601 course and in Certified Modeling and Simulation Professional examination preparation courses.
  - 7) Number of hours estimated to deliver/teach module 11
  - 8) Proposed delivery modalities Face-to-face lecture, synchronous distance learning (live audio/video connection), asynchronous distance learning (web or CD)
  - 9) Proposed references and texts (topics refer to these by number)
    - [1] R. M. Fujimoto, “Distributed Simulation and the High Level Architecture”, in W. B. Rouse and K. R. Boff (Editors), *Organizational Simulation*, John Wiley & Sons, Hoboken NJ, 2005, pp. 591-609.
    - [2] R. M. Fujimoto, “Parallel and Distributed Simulation”, in J. Banks (Editor), *Handbook of Simulation*, John Wiley & Sons, New York 1998, pp. 429-464.
    - [3] M. Petty, MSIM 601 and CMSP Exam Prep lecture notes.
    - [4] O. Balci, “Verification, Validation, and Testing”, in J. Banks (Editor), *Handbook of Simulation*, John Wiley & Sons, New York 1998, pp. 335-393.
  - 10) Module learning objectives Correspond to sub-ESRs for ESR P4

- a) P4.1 Define the different testing environments (live, virtual, and constructive) and compare the relative advantages and disadvantages of each environment for different product and system testing applications.
- b) P4.2 Identify the attributes of an M&S application that determine whether a live, virtual, constructive, or combination environment would be most appropriate, and the values for those attributes that indicate each type.
- c) P4.3 List significant and widely used models, standalone simulations, confederated simulations, data sets, and interoperability protocol standards applied in the different environments.
- d) P4.4 Describe approaches to testing and validating models and simulations suitable for use in each of the environments, and identify degree of accuracy typically required in that environment.
- e) P4.5 Define the differences between standalone and federated simulation and give examples of each that have been used successfully in test and acquisition applications. Identify the attributes of an M&S application that determine whether a standalone simulation or a federation of interoperable simulations would be more appropriate, and the values for those attributes that indicate each type.
- f) P4.6 List current simulation interoperability protocol standards and describe the advantages and disadvantages of each in each of the different environments.
- g) P4.7 List existing resources in each of the environments, including model repositories, implemented federations of interoperable simulations, standalone simulations, standard object models, and accredited data sets, and describe the procedures for searching for resources within repositories of them.
- h) P4.8 Describe case studies of successful test and acquisition M&S applications in each of the different environments.

11) Course assessment plan End of module examination

12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)

- 1. Customizing live, virtual, and constructive environments for a specific application; P4.1; [1] [2] [3]
- 2. Determining the attributes of given M&S applications in live, virtual, and constructive environments; P4.2; to be determined
- 3. M&S application attributes in unusual applications and special cases; P4.2; to be determined
- 4. Recognizing significant, or potentially significant, items in live, virtual, and constructive environments; P4.3; to be determined
- 5. Performing testing and validation using existing methods in live, virtual, and constructive environments; P4.4; [4]
- 6. Applying standalone and interoperable simulations in test and acquisition M&S applications; P4.5; [1] [2] [3]
- 7. Attributes of M&S applications that determine whether a standalone or interoperable simulation would be more appropriate, and attribute values that indicate each type; P4.5; [1] [2] [3]

8. Applying interoperability protocol standards in test and acquisition M&S applications; P4.6; [1] [2] [3]
  9. Procedures for examining, acquiring, customizing, and using existing resources; P4.7; to be determined
  10. Adapting methods and lessons from a case study to a new test and acquisition M&S application; P4.8; to be determined
  11. Analyzing a test and acquisition M&S application for lessons learned; P4.8; to be determined
- 

1) Module name P4-M M&S environments and interoperability (Mastery)

2) Coordinator

Dr. Mikel D. Petty, UAH CMSA, 256-824-4368, pettym@uah.edu

3) Module description This module comprises topics to provide training to a “Mastery” level of competence for program managers, systems engineers, and test and evaluation workforce members for ESR P4: Apply M&S in different testing environments (Live, Virtual, and Constructive). Apply both standalone and interoperable simulations in appropriate situations. Select among different simulation interoperability standards when necessary.

4) ESRs that the module supports and the corresponding level of competence  
P4 Mastery

5) Prerequisites assumed and the corresponding level of competence Module P4-A

6) Module maturity Portions of the material have been taught by the module coordinator in both Old Dominion University’s MSIM 601 course and in Certified Modeling and Simulation Professional examination preparation courses.

7) Number of hours estimated to deliver/teach module 10

8) Proposed delivery modalities Face-to-face lecture, synchronous distance learning (live audio/video connection), asynchronous distance learning (web or CD)

9) Proposed references and texts (topics refer to these by number)

[1] R. M. Fujimoto, “Distributed Simulation and the High Level Architecture”, in W. B. Rouse and K. R. Boff (Editors), *Organizational Simulation*, John Wiley & Sons, Hoboken NJ, 2005, pp. 591-609.

[2] R. M. Fujimoto, “Parallel and Distributed Simulation”, in J. Banks (Editor), *Handbook of Simulation*, John Wiley & Sons, New York 1998, pp. 429-464.

[3] M. Petty, MSIM 601 and CMSP Exam Prep lecture notes.

[4] O. Balci, “Verification, Validation, and Testing”, in J. Banks (Editor), *Handbook of Simulation*, John Wiley & Sons, New York 1998, pp. 335-393.

- 10) Module learning objectives Correspond to sub-ESRs for ESR P4
  - a) P4.1 Define the different testing environments (live, virtual, and constructive) and compare the relative advantages and disadvantages of each environment for different product and system testing applications.
  - b) P4.2 Identify the attributes of an M&S application that determine whether a live, virtual, constructive, or combination environment would be most appropriate, and the values for those attributes that indicate each type.
  - c) P4.3 List significant and widely used models, standalone simulations, confederated simulations, data sets, and interoperability protocol standards applied in the different environments.
  - d) P4.4 Describe approaches to testing and validating models and simulations suitable for use in each of the environments, and identify degree of accuracy typically required in that environment.
  - e) P4.5 Define the differences between standalone and federated simulation and give examples of each that have been used successfully in test and acquisition applications. Identify the attributes of an M&S application that determine whether a standalone simulation or a federation of interoperable simulations would be more appropriate, and the values for those attributes that indicate each type.
  - f) P4.6 List current simulation interoperability protocol standards and describe the advantages and disadvantages of each in each of the different environments.
  - g) P4.7 List existing resources in each of the environments, including model repositories, implemented federations of interoperable simulations, standalone simulations, standard object models, and accredited data sets, and describe the procedures for searching for resources within repositories of them.
  - h) P4.8 Describe case studies of successful test and acquisition M&S applications in each of the different environments.
- 11) Course assessment plan End of module examination.
- 12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)
  1. Selecting among live, virtual, and constructive environments for a specific application based on environment characteristics; P4.1; [1] [2] [3]
  2. Designing and integrating hybrid live, virtual, and constructive environments for specialized applications; P4.1; [1] [2] [3]
  3. Selecting among live, virtual, and constructive environments based on M&S application attributes; P4.2; [1] [2] [3]
  4. Selecting among available widely used items for an application within live, virtual, and constructive environments; P4.3; [1] [2] [3]
  5. Selecting appropriate testing and validation methods in live, virtual, and constructive environments; P4.4; [4]
  6. Developing new, enhanced, or hybrid environment-specific testing and validation methods in live, virtual, and constructive environments; P4.4; to be determined
  7. Selecting among standalone and interoperable simulations based on the attributes of an M&S application; P4.5; [1] [2] [3]

8. Selecting among current interoperability protocol standards for a given M&S application in live, virtual, and constructive environments; P4.6; [1] [2] [3]
  9. Selecting among existing resources for use in test and acquisition M&S application in live, virtual, and constructive environments; P4.7; to be determined
  10. Selecting a case study relevant to a planned test and acquisition M&S application and extracting pertinent lessons learned; P4.8; to be determined
- 

*Course Name:* M&S Taxonomies, Hierarchies, and Architectures

*Course coordinator*

Robert R. Lutz  
MS 25-262  
11100 Johns Hopkins Rd.  
Laurel, MD 20723u

*Course description*

Application-based characterization of M&S applications by taxonomy (live, virtual, and constructive) and hierarchy (campaign, missions, engagement, and engineering), including selection criteria. Also includes the role of M&S in systems architecture development and implementation, along with resulting M&S architecture solutions.

*Modules incorporated into course*

P4(1)-G M&S Taxonomies and Hierarchies (General awareness)  
P4(1)-U M&S Taxonomies and Hierarchies (Understanding)  
P4(1)-A/M M&S Taxonomies and Hierarchies (Application/Mastery)

*ESRs that the course supports and the corresponding level of mastery*

ESR P4(1) General awareness, Understanding, Application, and Mastery

*Prerequisites assumed, and corresponding level of mastery*

Basic familiarity with M&S concepts, equivalent to MSIAC M&S Staff Officers Course.

*Course maturity*

Not previously taught as a course, although some of this material has been taught in other courses (e.g., Certified Modeling and Simulation Professional examination preparation course) and in M&S tutorials given by external M&S organizations (e.g., I/ITSEC).

*Number of contact hours and pace contemplated*

Semester course: 8 lecture hours per week for 3 days.

*Proposed delivery modality*

Face-to-face lecture would be preferred, but asynchronous distance learning (web or CD) is also possible.

*Proposed references and texts*

- [1] Piplani, L., Mercer J, Roop R., "Systems Acquisition Manager's Guide for the Use of Models and Simulations", Defense Systems Management College, 1994.
- [2] Law A., "Simulation Modeling and Analysis", Fourth Edition, McGraw-Hill, 2007.
- [3] Lutz R., "Modeling and Simulation in the Systems Engineering Process", *Introduction to Systems Engineering Lecture Notes*, 2006.
- [4] Lutz R., "Simulation Based Acquisition: Concepts and Trends", INCOSE Meeting Presentation, 2002.
- [5] "Operation of the Defense Acquisition System", DoDI 5000.2, 2003.
- [6] "Systems Engineering – System Life Cycle Processes", IEEE 15288, 2004.
- [7] "High Level Architecture", IEEE 1516, 2001.

*Course learning objectives*

Correspond to sub-ESRs for ESR P4(1):

- a) P4(1).1 Provides an overview of basic M&S concepts, including benefits and limitations of using M&S.
- b) P4(1).2 Provides a general overview of how M&S supports systems engineering, including the different classes of M&S users (e.g., T&E, training, analysis, ...)
- c) P4(1).3 Provides an introduction to the Live, Virtual, and Constructive taxonomy of models and simulations, and discusses the criteria for selecting when each is most appropriate.
- d) P4(1).4 Provides an introduction to the concept of model fidelity and model resolution. Discusses the standard M&S model hierarchy from campaign-level to engineering-level, and the criteria for selecting when each is most appropriate.
- e) P4(1).5 Provides an introduction to the concept of "architecture", including how M&S is used to support the evaluation of system architectures.
- f) P4(1).6 Describes the concept of "architecture" from the M&S perspective, including modern mechanisms for developing and describing M&S architectures.

*Course assessment plan*

Results of team projects performed on last day.

*Topic list by hour of instruction and reference*

Listed for each hour are topic description, related sub-ESR, and reference (if any).

- 1. Identify and describe basic M&S concepts, including benefits and limitations of using M&S, P4(1).1, [1], [2]
- 2. Provide examples that illustrate the fundamental concepts underlying M&S and demonstrate M&S benefits and limitations, P4(1).1, [1], [2]
- 3. Describe how M&S supports systems engineering, including the different classes of M&S users (e.g., T&E, training, analysis, ...), P4(1).2, [1], [3], [4]
- 4. Show how M&S supports the DoD 5000 systems acquisition process, including examples across the various classes of M&S users (e.g., T&E, training, analysis, ...), P4(1).2, [1], [3], [4], [5]
- 5. Show how M&S supports the DoD 5000 systems acquisition process, including examples across the various classes of M&S users (continuation of previous lecture), P4(1).2, [1], [3], [4], [5]



6. Show how M&S supports the IEEE 15288 systems engineering process. Provide examples where appropriate, P4(1).2, [6]
7. Introduce the Live, Virtual, and Constructive (LVC) taxonomy of models and simulations, P4(1).3, [1]
8. Conclude LVC introduction (from previous lecture). Explain the criteria for selecting among Live, Virtual, and Constructive M&S assets for different types of applications, P4(1).3, [1]
9. Conclude selection criteria discussion (from previous lecture). Using case studies, determine an appropriate set of selection criteria for choosing among Live, Virtual, and Constructive M&S assets within each application area, and apply those criteria appropriately, P4(1).3
10. Using case studies, determine an appropriate set of selection criteria for choosing among Live, Virtual, and Constructive M&S assets within each application area, and apply those criteria appropriately (continuation of previous lecture), P4(1).3
11. Conclude LVC case studies from previous lecture. Introduce the concept of model fidelity and model resolution. Outline the standard M&S model hierarchy from campaign-level to engineering-level, P4(1).4, [1]
12. Conclude discussion of model fidelity, model resolution, and model hierarchy (continuation of previous lecture), P4(1).4, [1]
13. Explain the criteria for selecting among M&S assets across the various levels of the M&S hierarchy for different types of applications, P4(1).4, [1]
14. Using case studies, determine an appropriate set of selection criteria for choosing among M&S assets across the various levels of the M&S hierarchy for each application area, and apply those criteria appropriately, P4(1).4
15. Using case studies, determine an appropriate set of selection criteria for choosing among M&S assets across the various levels of the M&S hierarchy for each application area, and apply those criteria appropriately (continuation of previous lecture), P4(1).4
16. Introduce the concept of "architecture" and how it supports systems engineering, P4(1).5, [4]
17. Describe how M&S is used to support the evaluation of system architectures, P4(1).5, [3], [4]
18. Illustrate how M&S is used to support the evaluation of system architectures through a chosen set of examples, P4(1).5, [3], [4]
19. Illustrate how M&S is used to support the evaluation of system architectures through a chosen set of examples (continuation of previous lecture), P4(1).5, [3], [4]
20. Demonstrate the use of an M&S tool to evaluate a system architecture. Discuss the different types of M&S tools that are available to support this function, P4(1).5
21. Demonstrate the use of an M&S tool to evaluate a system architecture. Discuss the different types of M&S tools that are available to support this function (continuation of previous lecture), P4(1).5
22. Describe the concept of "architecture" from the M&S perspective, including modern mechanisms for developing and describing M&S architectures., P4(1).6, [3], [4]
23. Provide examples of existing M&S architectures. For one such example, show how the architecture was developed, P4(1).6, [3], [4]

24. Analyze a selected M&S architecture. Discuss the relevant design issues and how they were resolved, P4(1).6, [7]

**P5) Establish and write valid modeling and simulation requirements using a process that includes modeling and simulation needs analysis, generation of valid modeling and simulation requirements, functional decomposition and conceptual model development, and issuance of “built to” or “buy to” performance specifications. Understand how models and simulations evolve in fidelity, resolution, and scope as the program life cycle progresses.**

- 1) Module name: M&S Requirements
- 2) Module coordinator: Marsha Taliaferro-Gillis, Ph.D.  
6596 Main Street  
Gloucester, VA 23061  
(804)694-3173 (Office)  
(804)824-4663 (Cell)  
mtgillis@werneranderson.com
- 3) Module description: Establish and write valid modeling and simulation requirements using a process that includes modeling and simulation needs analysis, generation of valid modeling and simulation requirements, functional decomposition and conceptual model development, and issuance of “built to” or “buy to” performance specifications. Understand how models and simulations evolve in fidelity, resolution, and scope as the program life cycle progresses.
- 4) ESRs that the module supports: P5 (old P6)
- 5) Prerequisites assumed, and corresponding level of mastery:
- 6) Module maturity:
- 7) Number of hours estimated to teach: 20 (1 hour of introduction and overview)
- 8) Proposed Delivery modality: face-to-face, on-line, VTC, resident, customer’s site
- 9) Proposed references and texts:

DoD. 2004. *Defense Acquisition Guidebook*. <https://akss.dau.mil/dag/>

DoD. 2006. *VV&A Recommended Practices Guide*. <http://vva.dmsso.mil/>

Law, A.M., and W.D. Kelton, *Simulation Modeling and Analysis*, Second Edition, McGraw-Hill, Boston, 1991

Rubenstein, R. Y., B. Melamel. 1998. *Modern Simulation and Modeling*. John Wiley and Sons, Inc., New York, NY.

## 10) Module learning objectives:

- P5.1 Describe the M&S development and VV&A lifecycle (for COTS, GOTS and new development M&S)
- P5.2 Identify the three domains of M&S requirements (user domain, problem domain, and simulation domain)
- P5.3 Describe the types of representational requirements (e.g., entities, actions, tasks, interactions, behaviors) in M&S and standard methods for capturing them (e.g. UML, conceptual model descriptions)
- P5.4 Describe how M&S requirements, representational requirements, acceptability criteria, and intended use support conceptual model development and validation
- P5.5 Describe the M&S process differences between legacy (no, minor & major modifications) and new development models
- P5.6 Describe the work products available in M&S development and their role in VV&A
- P5.7 Describe how M&S fidelity, resolution, and scope changes across the acquisition lifecycle (e.g., concept refinement to DT to OTA to OT to training)
- P5.8 Describe the role of acceptability criteria in the VV&A process and its relationship to M&S requirements
- P5.9 Given a case study, select those requirements which are appropriate for M&S
- P5.10 Given a case study and sample acquisition documents (TEMP, CDD, ICD, PSPEC), develop or evaluate requirements for M&S

## 11) Course assessment plan: projects, and exams

## 12) Topic list by hour of instruction and reference.

Competency Level: Understanding

i) Hour 1: Introduction and Overview (course notes and syllabus)

*Competency Level: Understanding*

ii) Hour 2: M&S development and VV&A lifecycle for COTS and GOTS (P5.1)

- Law, A.M., and W.D. Kelton, *Simulation Modeling and Analysis, Second Edition*, McGraw-Hill, Boston, 1991
- DoD. 2004. *Defense Acquisition Guidebook*. <https://akss.dau.mil/dag/>
- DoD. 2006. *VV&A Recommended Practices Guide*. <http://vva.dmsi.mil/>

*Competency Level: Understanding*

iii) Hour 3: M&S development and VV&A lifecycle for new development M&S (P5.1)

- Law, A.M., and W.D. Kelton, *Simulation Modeling and Analysis, Second Edition*, McGraw-Hill, Boston, 1991
- DoD. 2006. *VV&A Recommended Practices Guide*. <http://vva.dmsomil/>

*Competency Level: General Awareness*

- iv) Hour 4: The three domains of M&S requirements (P5.2)
  - user domain
  - problem domain
  - simulation domain
- Law, A.M., and W.D. Kelton, *Simulation Modeling and Analysis, Second Edition*, McGraw-Hill, Boston, 1991

*Competency Level: Understanding*

- v) Hour 5: Representational requirements in M&S and standard methods for capturing them (P5.3)
  - UML
  - conceptual Model Descriptions
  - entities
  - actions
- Law, A.M., and W.D. Kelton, *Simulation Modeling and Analysis, Second Edition*, McGraw-Hill, Boston, 1991

*Competency Level: Understanding*

- vi) Hour 6: Representational requirements in M&S and standard methods for capturing them (P5.3)
  - tasks
  - interactions
  - behaviors
- Law, A.M., and W.D. Kelton, *Simulation Modeling and Analysis, Second Edition*, McGraw-Hill, Boston, 1991

*Competency Level: Understanding*

- vii) Hour 7: Conceptual model development and validation (P5.4)
  - M&S Requirements
  - representational Requirements
- Law, A.M., and W.D. Kelton, *Simulation Modeling and Analysis, Second Edition*, McGraw-Hill, Boston, 1991
- DoD. 2006. *VV&A Recommended Practices Guide*. <http://vva.dmsomil/>

*Competency Level: Understanding*

- viii) Hour 8: Conceptual model development and validation (P5.4)
  - acceptability Criteria
  - intended Use
- Law, A.M., and W.D. Kelton, *Simulation Modeling and Analysis, Second Edition*, McGraw-Hill, Boston, 1991
- DoD. 2006. *VV&A Recommended Practices Guide*. <http://vva.dmsso.mil/>

*Competency Level: General Awareness*

- ix) Hour 9: M&S process differences between legacy (no, minor & major modifications) and new development models (P5.5)
  - Law, A.M., and W.D. Kelton, *Simulation Modeling and Analysis, Second Edition*, McGraw-Hill, Boston, 1991

*Competency Level: Understanding*

- x) Hour 10: M&S process differences between legacy (no, minor & major modifications) and new development models (P5.5)
  - Law, A.M., and W.D. Kelton, *Simulation Modeling and Analysis, Second Edition*, McGraw-Hill, Boston, 1991

*Competency Level: General Awareness*

- xi) Hour 11: Work products available in M&S development and their role in VV&A (P5.6)
  - Law, A.M., and W.D. Kelton, *Simulation Modeling and Analysis, Second Edition*, McGraw-Hill, Boston, 1991
  - Rubenstein, R. Y., B. Melamel. 1998. *Modern Simulation and Modeling*. John Wiley and Sons, Inc., New York, NY.
  - DoD. 2006. *VV&A Recommended Practices Guide*. <http://vva.dmsso.mil/>

*Competency Level: Understanding*

- xii) Hour 12: Work products available in M&S development and their role in VV&A (P5.6)
  - Law, A.M., and W.D. Kelton, *Simulation Modeling and Analysis, Second Edition*, McGraw-Hill, Boston, 1991
  - Rubenstein, R. Y., B. Melamel. 1998. *Modern Simulation and Modeling*. John Wiley and Sons, Inc., New York, NY.

- DoD. 2006. *VV&A Recommended Practices Guide*. <http://vva.dmsso.mil/>

*Competency Level: Understanding*

- xiii) Hour 13: Changes in M&S fidelity, resolution, and scope across the acquisition lifecycle (P5.7)
  - changes from Concept Refinement through DT and OTA
  - a. Law, A.M., and W.D. Kelton, *Simulation Modeling and Analysis, Second Edition*, McGraw-Hill, Boston, 1991
  - b. DoD. 2004. *Defense Acquisition Guidebook*. <https://akss.dau.mil/dag/>
  - c. DoD. 2006. *VV&A Recommended Practices Guide*. <http://vva.dmsso.mil/>

*Competency Level: Understanding*

- xiv) Hour 14: Changes M&S fidelity, resolution, and scope across the acquisition lifecycle (P5.7)
  - changes from OTA through OT and training
  - Law, A.M., and W.D. Kelton, *Simulation Modeling and Analysis, Second Edition*, McGraw-Hill, Boston, 1991
  - DoD. 2004. *Defense Acquisition Guidebook*. <https://akss.dau.mil/dag/>
  - DoD. 2006. *VV&A Recommended Practices Guide*. <http://vva.dmsso.mil/>

*Competency Level: Understanding*

- xv) Hour 15: Acceptability criteria in the VV&A process (P5.8)
  - Law, A.M., and W.D. Kelton, *Simulation Modeling and Analysis, Second Edition*, McGraw-Hill, Boston, 1991
  - DoD. 2006. *VV&A Recommended Practices Guide*. <http://vva.dmsso.mil/>

*Competency Level: Understanding*

- xvi) Hour 16: Acceptability criteria in the VV&A process and its relationship to M&S requirements (P5.8)
  - Law, A.M., and W.D. Kelton, *Simulation Modeling and Analysis, Second Edition*, McGraw-Hill, Boston, 1991
  - DoD. 2006. *VV&A Recommended Practices Guide*. <http://vva.dmsso.mil/>

*Competency Level: Application*

xvii) Hour 17: M&S Selection Project (P5.9)

- Law, A.M., and W.D. Kelton, *Simulation Modeling and Analysis, Second Edition*, McGraw-Hill, Boston, 1991
- DoD. 2006. *VV&A Recommended Practices Guide*. <http://vva.dmsomil/>

*Competency Level: Application*

xviii) Hour 18: M&S Selection Project (P5.9)

- Law, A.M., and W.D. Kelton, *Simulation Modeling and Analysis, Second Edition*, McGraw-Hill, Boston, 1991
- DoD. 2006. *VV&A Recommended Practices Guide*. <http://vva.dmsomil/>

*Competency Level: Mastery*

xix) Hour 19: M&S Selection Project (P5.9)

- Law, A.M., and W.D. Kelton, *Simulation Modeling and Analysis, Second Edition*, McGraw-Hill, Boston, 1991
- DoD. 2006. *VV&A Recommended Practices Guide*. <http://vva.dmsomil/>

*Competency Level: Application*

xx) Hour 20: M&S Requirements Development and Evaluation Project (P5.10)

- Law, A.M., and W.D. Kelton, *Simulation Modeling and Analysis, Second Edition*, McGraw-Hill, Boston, 1991
- DoD. 2006. *VV&A Recommended Practices Guide*. <http://vva.dmsomil/>

*Competency Level: Application*

xxi) Hour 21: M&S Requirements Development and Evaluation Project (P5.10)

- Law, A.M., and W.D. Kelton, *Simulation Modeling and Analysis, Second Edition*, McGraw-Hill, Boston, 1991
- DoD. 2006. *VV&A Recommended Practices Guide*. <http://vva.dmsomil/>

*Competency Level: Mastery*

xxii) Hour 22: M&S Requirements Development and Evaluation Project (P5.10)



- Law, A.M., and W.D. Kelton, *Simulation Modeling and Analysis, Second Edition*, McGraw-Hill, Boston, 1991
- DoD. 2006. *VV&A Recommended Practices Guide*. <http://vva.dmsomil/>

*Competency Level: Mastery*

xxiii) Hour 23: M&S Requirements Development and Evaluation Project (P5.10)

- Law, A.M., and W.D. Kelton, *Simulation Modeling and Analysis, Second Edition*, McGraw-Hill, Boston, 1991
- DoD. 2006. *VV&A Recommended Practices Guide*. <http://vva.dmsomil/>

**P6) Estimate the cost, develop a schedule, and assess a modeling and simulation plan. Identify the areas of risk and develop a mitigation strategy.**

- 1) Module name: M&S Plan Assessment and Risk Mitigation Strategy
- 2) Module coordinator: Anthony Genna  
UCSD Extension  
Assistant Director,  
Defense Technology  
agenna@ucsd.edu  
858-603-2170 (cell)
- 3) Module description: Estimate the cost, develop a schedule, and assess a modeling and simulation plan. Identify the areas of risk and develop a mitigation strategy.
- 4) ESRs that the module supports and the corresponding level of mastery:
- 5) Prerequisites assumed, and corresponding level of mastery: training and education (i.e., BS/MS degree or DAU/DoD courses, certifications, etc.) meeting requirements of current position and/or rank/grade/rate.

In addition it is recommended that student have academic training or OJT equivalent to the following levels of competency:

- (1) M&S “GA” module: General Awareness (GA) in current job position
- (2) M&S “UN” module: Understanding (UN) in current job position
- (3) M&S “AP” module: Application (AP) in current job position
- (4) M&S “MA” module: Mastery (MA) in current job position
- 6) Module maturity: TBD
- 7) Number of hours estimated to deliver/teach module: 25 hours
  - a) General Awareness 4 hours
  - b) Understanding 6 hours
  - c) Application 7 hours
  - d) Mastery 8 hours
- 8) Proposed Delivery modality:
  - Face-to-face, VTC, customer’s site.
- 9) Proposed references and texts:
 

Text will be a current, entry-level M&S text to be identified by the instructor at time of delivery. Additional reference material will include current available literature selected by the instructor for practical application in support of the curriculum. Other supporting

text/reference material will be student contributions of relevant material from their experience.

- Acquisition M&S Master Plan, 17Apr06

10) Module learning objectives: Estimate the cost, develop a schedule, and assess a modeling and simulation plan. Identify the areas of risk and develop a mitigation strategy.

P6.1	Demonstrate competency level described in above matrix to relate acquisition cost models to M&S and risk mitigation using M&S tools.
P6.2	Demonstrate competency level described in above matrix to define measurable performance factors for a given case study.
P6.3	Demonstrate competency level described in above matrix to define cost requirements and justifications as they relate to an M&S plan.
P6.4	Demonstrate competency level described in above matrix to develop a schedule for an M&S plan.
P6.5	Demonstrate competency level described in above matrix to assess effectiveness (cost and schedule) of an M&S plan.
P6.6	Demonstrate competency level described in above matrix to develop a risk mitigation strategy for implementing the M&S plan.

11) Course assessment plan: Team projects/case studies, discussion, written questions.

12) Topic list by hour of instruction and reference:

The hours of instruction are categorized based on the level of competency required. As a result of this format hour structure starts at a level of general awareness and progresses through mastery. This will allow the course material to be easily segmented into each one of the 4 levels of competency.

Hour	Subject Description	Ref:
1-4	Introduction and overview of the M&S plan process (.ppt)	Ref [1]
5	Student will demonstrate basic understanding of cost models and risk mitigation topics (.ppt)	Ref [1]
6	Student will demonstrate basic understanding of performance factor definition (.ppt)	Ref [1]
7	Student will demonstrate basic understanding of cost requirements and justifications (.ppt)	Ref [1]
8	Student will demonstrate basic understanding of M&S plan	Ref [1]

Hour	Subject Description	Ref:
	scheduling (.ppt)	
9	Student will demonstrate basic understanding of M&S plan effectiveness assessment (.ppt)	Ref [1]
10	Student will demonstrate basic understanding of M&S plan risk mitigation (.ppt)	Ref [1]
11	Student will demonstrate ability to use M&S application techniques that support cost models and risk mitigation topics.	Ref [1]
12	Student will demonstrate ability to use M&S application techniques that support performance factor definition/determination.	Ref [1]
13	Student will demonstrate ability to use M&S application techniques that support cost requirements and justification decision-making.	Ref [1]
14	Student will demonstrate ability to use M&S application techniques that support M&S plan scheduling.	Ref [1]
15-16	Student will demonstrate ability to use M&S application techniques that support M&S plan effectiveness assessment.	Ref [1]
17	Student will demonstrate ability to use M&S application techniques that support M&S plan risk mitigation.	Ref [1]
18-19	Student will perform M&S plan and risk mitigation strategy development and related M&S Case Studies (.ppt)	Ref [1]
20-21	Student will perform M&S plan development and related M&S team project recognizing and/or determining cost, schedule and performance requirements.	Ref [1]
22	Student will demonstrate use of M&S tools to perform analysis and evaluation of M&S plan effectiveness (ppt.)	Ref [1]
23-24	Student will demonstrate use of M&S tools to perform analysis and evaluation of M&S plan in a team project.	Ref [1]
25	Student will demonstrate use of M&S tools to perform analysis and evaluation of risk mitigation in a team project.	Ref [1]

Ref [1] TBD by NPS partners.

**P7) Incorporate modeling and simulation, through a Simulation Support Plan or similar process, into a systems engineering plan and a test and evaluation master plan.**

- 1) Module name: Simulation Support Plan (SSP)
- 2) Module coordinator/POC: Anthony Genna  
UCSD Extension  
Assistant Director,  
Defense Technology  
agenna@ucsd.edu  
858-603-2170 (cell)
- 3) Module description: Incorporate modeling and simulation, through a Simulation Support Plan (SSP) or similar process, into a Systems Engineering Plan (SEP) and a Test and Evaluation Master Plan (TEMP).
- 4) ESR's that the module supports and the corresponding level of mastery:
- 5) Prerequisites assumed, and corresponding level of mastery: training and education (i.e., BS/MS degree or DAU/DoD courses, certifications, etc.) meeting requirements of current position and/or rank/grade/rate.

In addition it is recommended that student have academic training or OJT equivalent to the following levels of competency:

- (1) M&S "GA" module: General Awareness in current job position
- (2) M&S "UN" module: Understanding in current job position
- (3) M&S "AP" module: Application in current job position
- (4) M&S "MA" module: Mastery in current job position
- 6) Module maturity: has it been taught, and if so, a brief history: TBD
- 7) Number of hours estimated to deliver/teach module: 36 Hours
 

(1) General Awareness	4 hours
(2) Understanding	7.5 hours
(3) Application	14 hours
(4) Mastery	10.5 hours
- 8) Proposed Delivery modality:  
- Face-to-face, VTC, resident, customer's site.
- 10) Proposed references and texts:  
Text will be a current, entry-level M&S text to be identified by the instructor at time of delivery. Additional reference material will include current available literature selected by the instructor for practical application in support of the curriculum. Other supporting

text/reference material will be student contributions of relevant material from their experience.

- 21ST Century Surface Combatant Executive Summary Modeling and Simulation Master Plan Version 1.0 SC-21 Program Office, NAVSEA Washington DC, 17Oct97

- Systems Engineering Plan (SEP) Preparation Guide, ver1.0, 15Aug05

- Memorandum, HQ DA, DAMO-ZS, 18 Sep 02, subject: Army Model and Simulation Office (AMSO) Position on the Simulation Support Plan (SSP) Requirement

- Memorandum, HQ TRADOC, ATCD-ZC, 26 Sep 02, subject: Simulation Support Plan (SSP)

10) Module learning objectives: Incorporate modeling and simulation, through a Simulation Support Plan (SSP) or similar process, into a Systems Engineering Plan (SEP) and a Test and Evaluation Master Plan (TEMP).

P7.1	Demonstrate competency level described in above matrix to define a Simulation Support Plan (SSP) and the relationship to using M&S for acquisition decisions.
P7.2	Demonstrate competency level described in above matrix to show efficient use of SSP across life cycle phases of development.
P7.3	Demonstrate competency level described in above matrix to show how an integrated SSP, SEP and TEMP can be leveraged to reduce risk, cost and schedule issues.
P7.4	Demonstrate competency level described in above matrix to define elements of System of Systems (SOS) and interoperability across SSP.
P7.5	Demonstrate competency level described in above matrix to incorporate the SSP into a System Engineering Plan (SEP).
P7.6	Demonstrate competency level described in above matrix to integrate an SSP into a Test and Evaluation Master Plan (TEMP).
P7.7	Demonstrate competency level described in above matrix to analyze the rationale for trade-off decisions and selections for SSP, SEP and TEMP.
P7.8	Demonstrate competency level described in above matrix to manage M&S resources and documentation of SSP, SEP and TEMP.
P7.9	Demonstrate competency level described in above matrix to create and analyze a case study encompassing SSP, SEP and TEMP.

10) Course assessment plan (projects, exams, papers, etc.)

- Team projects/case studies, discussion, written questions.

10) Topic list by hour of instruction and reference:

The hours of instruction are categorized based on the level of competency required. As a result of this format hour structure starts at a level of general awareness and progresses through mastery. This will allow the course material to be easily segmented into each one of the 4 levels of competency.

Hour	Subject Description	Ref:
1-4	Introduction and overview of a Simulation Support Plan (SSP) and its relationship to using M&S for acquisition decisions, and consideration of system of systems interoperability.	Ref [1]
5.0	Student will demonstrate basic understanding of using an SSP across life cycle phases of development.	Ref [1]
6.0	Student will demonstrate basic understanding of how an integrated SSP can reduce cost, schedule and program risk.	Ref [1]
7.0	Student will demonstrate basic understanding of a System Engineering Plan (SEP).	Ref [1]
8.0	Student will demonstrate basic understanding of a Test and Evaluation Master Plan (TEMP).	Ref [1]
9.0	Student will demonstrate basic understanding of integration and incorporation of an SSP into an SEP and a TEMP.	Ref [1]
9.5	Student will demonstrate basic understanding of trade-off decisions and their rationale.	Ref [1]
10.5	Student will demonstrate basic understanding of M&S resource management and documentation.	Ref [1]
11.5-13	Student will demonstrate ability to use M&S application techniques related using an SSP across life cycle phases of development.	Ref [1]
14-16	Student will demonstrate ability to use M&S application techniques related to cost, schedule and program risk reduction using an integrated SSP.	Ref [1]
17-20	Student will demonstrate ability to use M&S application techniques related to integration and incorporation of an SSP into an SEP and a TEMP.	Ref [1]
21-22	Student will demonstrate ability to use M&S application techniques related to trade-off decisions and their rationale.	Ref [1]
23	Student will demonstrate ability to use M&S application techniques related to M&S resource management and documentation.	Ref [1]
24-25.5	Class project: student will create a case study encompassing SSP, SEP and TEMP.	Ref [1]
26.5-27	Student will demonstrate use of M&S tools to support analysis and evaluation of using an SSP across life cycle phases of development.	Ref [1]
28-29	Student will demonstrate use of M&S tools in support of analysis and evaluation of how an integrated SSP can reduce cost, schedule and program risk. Includes case study.	Ref [1]
30-32	Student will demonstrate use of M&S tools in support of analysis and evaluation of trade-off decisions and their rationale. Includes case study.	Ref [1]
33-36	Class project: Student will demonstrate use of M&S tools to perform analysis and evaluation of a case study encompassing SSP, SEP and TEMP.	Ref [1]

Ref [1] TBD by NPS Partners.

**P8) Know and require the best practices and standards in modeling and simulation as developed in key case studies.**

- 1) Module name: Standards in Modeling and Simulation
- 2) Module coordinator: Marsha Taliaferro-Gillis, Ph.D.  
6596 Main Street  
Gloucester, VA 23061  
(804)694-3173 (Office)  
(804)824-4663 (Cell)  
mtgillis@werneranderson.com
- 3) Module description: Know and require the best practices and standards in modeling and simulation as developed in key case studies.
- 4) ESR that the Module supports and corresponding level of mastery. P8
- 5) Prerequisites assumed, and corresponding level of mastery.
- 6) Module maturity: none
- 7) Number of hours estimated to teach module: 23
- 8) Proposed Delivery modality: face-to-face, on-line, VTC, resident, customer's site
- 9) Proposed references and texts:

Bevan, Michelle T. 2001. Modeling and Simulation for Acquisition, Requirements and Training: The Army SMART Model. *The National Summit on U.S. Defense Policy: Acquisition, Research, Test and Evaluation*. IIT – Research Institute. Msiac Retrieved October 24 2007.

Bucknell University, Modeling and Simulation Best Practices for Wireless Ad Hoc. Retrieved October 24, 2007.  
<http://whitepapers.techrepublic.com.com/whitepapaer.aspx?docid=161862>

Christie, Alan M. 1999. Simulation: An Enabling Technology in Software Engineering. *Cross Talk-The Journal of Defense Software Engineering* Sei.cmu.edu.



Retrieved October 24, 2007.

<http://scholar.google.com/scholar?author=%22Christie%22+intitle:%22Simulation:+An...>

Davis, Alan M., Bersoff, Edward H., Comer, E. R. 1988. A strategy for comparing alternative software development life cycle models. Retrieved October 24, 2007.  
<http://scholar.google.com/scholar?q=%22Davis%22+intitle:%22A+strategy+for+c...>

Distributed Interactive Simulation. Doi.ieeecs.org. Retrieved October 24, 2007.  
<http://scholar.google.com/scholar?Q=author:%22Davis%22+intitle:%22A+strategy+for+c...>

High Level Architecture. Retrieved October 24, 2007.  
[http://en.wikipedia.org/wiki/High\\_Level\\_Architecture](http://en.wikipedia.org/wiki/High_Level_Architecture)

IEEE LTSC WG12 Standard for Information Technology – Education and Training Systems – Learning Objects and Metadata. Itsc.ieee.org/wg12/

Law, Averill M. 2006. *Simulation Modeling and Analysis with Expertfit Software*, The McGraw-Hill Companies, Boston.

Ledin, Jim. 2001. *Simulation Engineering: Build Better Embedded systems Faster*, C M P Books, ISBN-13 9781578200801.

Murray, K. J., S.V. Sheppard. 1988. Knowledge-based simulation model specification. *Simulation*, 1988. Sim.sagepub.com. Bell Communications Research, 444 Hoes lane – RRC Piscataway, New Jersey 08854.

Pace, Dale K. 2004. Modeling and Simulation Verification and Validation Challenges. *Johns Hopkins APL Technical Digest*. 25(2).

Richey, Frank, 2002. Modeling and Simulation CMMI: A Conceptual View. *Cross Talk-The Journal of Defense Software Engineering*. Retrieved October 24, 2007.  
<http://www.stsc.hill.af.mil/crosswalk/2002/03/richey.html>

Schrage, Michael D. 1999. *Serious Play: How the World's Best Companies Simulate to Innovate*. 1999. Harvard Business School Press, Boston. ISBN 13: 9780875848143

SISC Meeting 3-17-1999. [www.sisostds.org/index.php?Tg=fileman&idx=get&id=Y&path=&file=SISC\\_99\\_03\\_17\\_rev](http://www.sisostds.org/index.php?Tg=fileman&idx=get&id=Y&path=&file=SISC_99_03_17_rev). Retrieved October 24, 2007. <http://www.google.com/search?hl=en&q=HLA+Standards&btnG+Search>

10) Module learning objectives:

P8.1 Identify best practices in M&S planning

- P8.2 Identify best practices in M&S tool development (requirements, conceptual modeling)
- P8.3 Identify best practices in M&S federation development (DIS, HLA, IEEE standards)
- P8.4 Identify best practices in software development as it applies to M&S (IEEE standards, configuration management, maturity model standards)
- P8.5 Identify best practices in VV&A (maturity model, IEEE standards)
- P8.6 Apply a sample M&S Support Plan to provide best use of M&S across all stages of the acquisition lifecycle.
- P8.7 Analyze a sample V&V report for inclusion of best practices in VV&A.
- P8.8 Given a case study, analyze the benefit of M&S best practices across all components of the M&S development lifecycle.
- P8.9 Given a case study, analyze the benefit of M&S best practices across all components of the acquisition life-cycle.

11) Module assessment plan: projects, and exams

12) Topic list by hour of instruction and reference:

*Competency Level: General Awareness*

- i. Hour 1: Identify Best Practices in M&S
  - best practices
  - M&S planning
  - Ledin, Jim. 2001. *Simulation Engineering: Build Better Embedded systems Faster*, C M P Books, ISBN-13 9781578200801.
  - Bucknell University, Modeling and Simulation Best Practices for Wireless Ad Hoc. Retrieved October 24, 2007.  
<http://whitepapers.techrepublic.com.com/whitepapaer.aspx?docid=161862>

*Competency Level: General Awareness*

- ii. Hour 2: Identify best practices in M&S tool development (requirements, conceptual modeling)
  - tool development
  - conceptual modeling
  - Schrage, Michael D. 1999. *Serious Play: How the World's Best Companies Simulate to Innovate*. 1999. Harvard Business School Press, Boston. IBSN 13: 9780875848143

*Competency Level: General awareness*

- iii. Hour 3: Identify best practices in M&S tool development (requirements, conceptual modeling)
  - tool development

- conceptual modeling
- Schrage, Michael D. 1999. *Serious Play: How the World's Best Companies Simulate to Innovate* 1999. Harvard Business School Press, Boston. ISBN 13: 9780875848143

*Competency Level: Understanding*

- iv. Hour 4: Identify best practices in M&S tool development (requirements, conceptual modeling)
  - tool development
  - conceptual modeling
- Schrage, Michael D. 1999. *Serious Play: How the World's Best Companies Simulate to Innovate* 1999. Harvard Business School Press, Boston. ISBN 13: 9780875848143

*Competency Level: General Awareness*

- v. Hour 5: Identify best practices in M&S federation development (DIS, HLA, IEEE standards)
  - M&S federation development
  - DIS standards
  - HLA standards
  - IEEE standards
- Distributed Interactive Simulation. Doi.ieeeecs.org. Retrieved October 24, 2007. <http://scholar.google.com/scholar?Q=author:%22Davis%22+intitle:%22A+strategy+for+c...>
- High Level Architecture. Retrieved October 24, 2007. [http://en.wikipedia.org/wiki/High\\_Level\\_Architecture](http://en.wikipedia.org/wiki/High_Level_Architecture)
- SISC Meeting 3-17-1999. [www.sisostds.org/index.php?Tg=fileman&idx=get&id=Y&path=&file=SISC\\_99\\_03\\_17\\_rev](http://www.sisostds.org/index.php?Tg=fileman&idx=get&id=Y&path=&file=SISC_99_03_17_rev). Retrieved October 24, 2007. <http://www.google.com/search?hl=en&q=HLA+Standards&btnG=Search>
- IEEE LTSC WG12 Standard for Information Technology – Education and Training Systems – Learning Objects and Metadata. Itsc.ieee.org/wg12/

*Competency Level: General Awareness*

- vi. Hour 6: Identify best practices in software development as it applies to M&S (IEEE standards, configuration management, maturity model standards)
  - M&S software development
  - IEEE standards
  - configuration management
  - maturity model standards

- Law, Averill M. 2006. *Simulation Modeling and Analysis with Expertfit Software*, The McGraw-Hill Companies, Boston.
- IEEE LTSC WG12 Standard for Information Technology – Education and Training Systems – Learning Objects and Metadata. Itsc.ieee.org/wg12/

*Competency Level: General awareness*

- vii. Hour 7: Identify best practices in software development as it applies to M&S (IEEE standards, configuration management, maturity model standards)
- M&S software development
  - IEEE standards
  - configuration management
  - maturity model standards
  - Law, Averill M. 2006. *Simulation Modeling and Analysis with Expertfit Software*, The McGraw-Hill Companies, Boston.
  - IEEE LTSC WG12 Standard for Information Technology – Education and Training Systems – Learning Objects and Metadata. Itsc.ieee.org/wg12/

*Competency Level: General Awareness*

- viii. Hour 8: Identify best practices in VV&A (maturity model, IEEE standards)
- best practices in VV&A
  - maturity model
  - IEEE standards
  - Pace, Dale K. 2004. Modeling and Simulation Verification and Validation Challenges. *Johns Hopkins APL Technical Digest*. 25(2)
  - Richey, Frank, 2002. Modeling and Simulation CMMI: A Conceptual View. *Cross Talk-The Journal of Defense Software Engineering*. Retrieved October 24, 2007. <http://www.stsc.hill.af.mil/crosswalk/2002/03/richey.html>

*Competency Level: General awareness*

- ix. Hour 9: Identify best practices in VV&A (maturity model, IEEE standards)
- best practices in VV&A
  - maturity model
  - IEEE standards
  - Pace, Dale K. 2004. Modeling and Simulation Verification and Validation Challenges. *Johns Hopkins APL Technical Digest*. 25(2)

- Richey, Frank, 2002. Modeling and Simulation CMMI: A Conceptual View. *Cross Talk-The Journal of Defense Software Engineering*. Retrieved October 24, 2007.  
<http://www.stsc.hill.af.mil/crosswalk/2002/03/richey.html>

*Competency Level: Understanding*

- x. Hour 10: Identify best practices in VV&A (maturity model, IEEE standards)
- best practices in VV&A
  - maturity model
  - IEEE standards
  - Pace, Dale K. 2004. Modeling and Simulation Verification and Validation Challenges. *Johns Hopkins APL Technical Digest*. 25(2).
  - Richey, Frank, 2002. Modeling and Simulation CMMI: A Conceptual View. *Cross Talk-The Journal of Defense Software Engineering*. Retrieved October 24, 2007.  
<http://www.stsc.hill.af.mil/crosswalk/2002/03/richey.html>

*Competency Level: Application*

- xi. Hour 11: Identify best practices in VV&A (maturity model, IEEE standards)
- best practices in VV&A
  - maturity model
  - IEEE standards
  - Pace, Dale K. 2004. Modeling and Simulation Verification and Validation Challenges. *Johns Hopkins APL Technical Digest*. 25(2)
  - Richey, Frank, 2002. Modeling and Simulation CMMI: A Conceptual View. *Cross Talk-The Journal of Defense Software Engineering*. Retrieved October 24, 2007.  
<http://www.stsc.hill.af.mil/crosswalk/2002/03/richey.html>

*Competency Level: General Awareness*

- xii. Hour 12: Apply a sample M&S Support Plan to provide best use of M&S across all stages of the acquisition lifecycle
- M&S support plan
  - acquisition lifecycle
  - Ledin, Jim. 2001. *Simulation Engineering: Build Better Embedded Systems Faster*, C M P Books, ISBN-13 9781578200801.
  - Bucknell University, Modeling and Simulation Best Practices for Wireless Ad Hoc. Retrieved October 24, 2007.  
<http://whitepapers.techrepublic.com.com/whitepaper.aspx?docid=161862>

*Competency Level: Application*

- xiii. Hour 13: Apply a sample M&S Support Plan to provide best use of M&S across all stages of the acquisition lifecycle
- M&S support plan
  - acquisition lifecycle
  - Ledin, Jim. 2001. *Simulation Engineering: Build Better Embedded Systems Faster*, C M P Books, ISBN-13 9781578200801.
  - Bucknell University, Modeling and Simulation Best Practices for Wireless Ad Hoc. Retrieved October 24, 2007.  
<http://whitepapers.techrepublic.com.com/whitepaper.aspx?docid=161862>

*Competency Level...Application*

- xiv. Hour 14: Apply a sample M&S Support Plan to provide best use of M&S across all stages of the acquisition lifecycle
- M&S support plan
  - acquisition lifecycle
  - Ledin, Jim. 2001. *Simulation Engineering: Build Better Embedded Systems Faster*, C M P Books, ISBN-13 9781578200801.
  - Bucknell University, Modeling and Simulation Best Practices for Wireless Ad Hoc. Retrieved October 24, 2007.  
<http://whitepapers.techrepublic.com.com/whitepaper.aspx?docid=161862>

*Competency Level: General Awareness*

- xv. Hour 15: Analyze a sample V&V report for inclusion of best practices in VV&A.
- V&V report
  - VV&A best practices
  - Pace, Dale K. 2004. Modeling and Simulation Verification and Validation Challenges. *Johns Hopkins APL Technical Digest*. 25(2)
  - Richey, Frank, 2002. Modeling and Simulation CMMI: A Conceptual View. *Cross Talk-The Journal of Defense Software Engineering*. Retrieved October 24, 2007.  
<http://www.stsc.hill.af.mil/crosswalk/2002/03/richey.html>

*Competency Level: Mastery*

- xvi. Hour 16: Analyze a sample V&V report for inclusion of best practices in VV&A.
- V&V report

- VV&A best practices

- Pace, Dale K. 2004. Modeling and Simulation Verification and Validation Challenges. *Johns Hopkins APL Technical Digest*. 252
- Richey, Frank, 2002. Modeling and Simulation CMMI: A Conceptual View. *Cross Talk-The Journal of Defense Software Engineering*. Retrieved October 24, 2007.  
<http://www.stsc.hill.af.mil/crosswalk/2002/03/richey.html>

*Competency Level: Mastery*

xvii. Hour 17: Analyze a sample V&V report for inclusion of best practices in VV&A.

- V&V report
- VV&A best practices
- Pace, Dale K. 2004. Modeling and Simulation Verification and Validation Challenges. *Johns Hopkins APL Technical Digest*. 25(2)
- Richey, Frank, 2002. Modeling and Simulation CMMI: A Conceptual View. *Cross Talk-The Journal of Defense Software Engineering*. Retrieved October 24, 2007.  
<http://www.stsc.hill.af.mil/crosswalk/2002/03/richey.html>

*Competency Level: General Awareness*

xviii. Hour 18: Given a case study, analyze the benefit of M&S best practices across all components of the M&S development lifecycle

- M&S best practices
- M&S development lifecycle
- Murray, K. J., S.V. Sheppard. 1988. Knowledge-based simulation model specification. *Simulation*, 1988. Sim.sagepub.com. Bell Communications Research, 444 Hoes lane – RRC Piscataway, New Jersey 08854.
- Christie, Alan M. 1999. Simulation: An Enabling Technology in Software Engineering. *Cross Talk-The Journal of Defense Software Engineering Sei.cmu.edu*. Retrieved October 24, 2007.  
<http://scholar.google.com/scholar?author=%22Christie%22+intitle:%22Simulation:+An...>
- Davis, Alan M., Bersoff, Edward H., Comer, E. R. 1988. A strategy for comparing alternative software development life cycle models. Retrieved October 24, 2007.  
<http://scholar.google.com/scholar?q=%22Davis%22+intitle:%22A+strategy+for+c...>
- Bevan, Michelle T. 2001. Modeling and Simulation for Acquisition, Requirements and Training: The Army SMART Model. *The National Summit on U.S. Defense*

*Policy: Acquisition, Research, Test and Evaluation.* IIT – Research Institute. Msiac Retrieved October 24 2007.

*Competency Level: Mastery*

- xix. Hour 19: Given a case study, analyze the benefit of M&S best practices across all components of the M&S development lifecycle
- M&S best practices
  - M&S development lifecycle
  - Murray, K. J., S.V.Sheppard. 1988. Knowledge-based simulation model specification. *Simulation*, 1988. Sim.sagepub.com. Bell Communications Research, 444 Hoes lane – RRC Piscataway, New Jersey 08854.
  - Christie, Alan M. 1999. Simulation: An Enabling Technology in Software Engineering. *Cross Talk-The Journal of Defense Software Engineering* Sei.cmu.edu. Retrieved October 24, 2007. <http://scholar.google.com/scholar?author=%22Christie%22+intitle:%22Simulation:+An...>
  - Davis, Alan M., Bersoff, Edward H., Comer, E. R. 1988. A strategy for comparing alternative software development life cycle models. Retrieved October 24, 2007. <http://scholar.google.com/scholar?q+:%22Davis%22+intitle:%22A+strategy+for+c...>
  - Bevan, Michelle T. 2001. Modeling and Simulation for Acquisition, Requirements and Training: The Army SMART Model. *The National Summit on U.S. Defense Policy: Acquisition, Research, Test and Evaluation.* IIT – Research Institute. Msiac Retrieved October 24 2007.

*Competency Level: Mastery*

- xx. Hour 20: Given a case study, analyze the benefit of M&S best practices across all components of the M&S development lifecycle
- M&S best practices
  - M&S development lifecycle
  - Murray, K. J., Sheppard, S. V. 1988. Knowledge-based simulation model specification, pp1-112, *Simulation*, 1988. Sim.sagepub.com. Bell Communications Research, 444 Hoes lane – RRC Piscataway, New Jersey 08854.
  - Christie, Alan M. 1999. Simulation: An Enabling Technology in Software Engineering. *Cross Talk-The Journal of Defense Software Engineering*. Retrieved from the web 24 October 2007. Sei.cmu.edu.
  - Davis, Alan M., Bersoff, Edward H., Comer, E. R. 1988. A strategy for comparing alternative software development life cycle models. Retrieved from the web 24 October 2007. Doi.ieeecs.org.



- Bevan, Michelle T. 2001. Modeling and Simulation for Acquisition, Requirements and Training: The Army SMART Model. *The National Summit on U.S. Defense Policy: Acquisition, Research, Test and Evaluation*. IIT – Research Institute. Retrieved from the web 24 October 2007.

*Competency Level: General Awareness*

- xxi. Hour 21: Given a case study, analyze the benefit of M&S best practices across all components of the acquisition life-cycle.
- M&S best practices
  - M&S acquisition lifecycle
  - Murray, K. J., S.V,Sheppard. 1988. Knowledge-based simulation model specification. *Simulation*, 1988. Sim.sagepub.com. Bell Communications Research, 444 Hoes lane – RRC Piscataway, New Jersey 08854.
  - Christie, Alan M. 1999. Simulation: An Enabling Technology in Software Engineering. *Cross Talk-The Journal of Defense Software Engineering Sei.cmu.edu*. Retrieved October24, 2007.  
<http://scholar.google.com/scholar?author=%22Christie%22+intitle:%22Simulation:+An...>
  - Davis, Alan M., Bersoff, Edward H., Comer, E. R. 1988. A strategy for comparing alternative software development life cycle models. Retrieved October 24, 2007.  
<http://scholar.google.com/scholar?q+:%22Davis%22+intitle:%22A+strategy+for+c...>
  - Bevan, Michelle T. 2001. Modeling and Simulation for Acquisition, Requirements and Training: The Army SMART Model. *The National Summit on U.S. Defense Policy: Acquisition, Research, Test and Evaluation*. IIT – Research Institute. Msiac Retrieved October 24 2007.

*Competency Level: Mastery*

- xxii. Hour 22: Given a case study, analyze the benefit of M&S best practices across all components of the acquisition lifecycle
- M&S best practices
  - M&S acquisition lifecycle
  - Murray, K. J., S.V,Sheppard. 1988. Knowledge-based simulation model specification. *Simulation*, 1988. Sim.sagepub.com. Bell Communications Research, 444 Hoes lane – RRC Piscataway, New Jersey 08854.
  - Christie, Alan M. 1999. Simulation: An Enabling Technology in Software Engineering. *Cross Talk-The Journal of Defense Software Engineering Sei.cmu.edu*. Retrieved October24, 2007.

<http://scholar.google.com/scholar?author=%22Christie%22+intitle:%22Simulation:+An...>

- Davis, Alan M., Bersoff, Edward H., Comer, E. R. 1988. A strategy for comparing alternative software development life cycle models. Retrieved October 24, 2007.  
<http://scholar.google.com/scholar?q=%22Davis%22+intitle:%22A+strategy+for+c...>
- Bevan, Michelle T. 2001. Modeling and Simulation for Acquisition, Requirements and Training: The Army SMART Model. *The National Summit on U.S. Defense Policy: Acquisition, Research, Test and Evaluation*. IIT – Research Institute. Msiac Retrieved October 24 2007.

*Competency Level: Mastery*

- xxiii. Hour 23: Given a case study, analyze the benefit of M&S best practices across all components of the acquisition life-cycle.
- M&S best practices
  - M&S acquisition lifecycle
  - Murray, K. J., S.V,Sheppard. 1988. Knowledge-based simulation model specification. *Simulation*, 1988. Sim.sagepub.com. Bell Communications Research, 444 Hoes lane – RRC Piscataway, New Jersey 08854.
  - Christie, Alan M. 1999. Simulation: An Enabling Technology in Software Engineering. *Cross Talk-The Journal of Defense Software Engineering Sei.cmu.edu*. Retrieved October24, 2007.  
<http://scholar.google.com/scholar?author=%22Christie%22+intitle:%22Simulation:+An...>
  - Davis, Alan M., Bersoff, Edward H., Comer, E. R. 1988. A strategy for comparing alternative software development life cycle models. Retrieved October 24, 2007.  
<http://scholar.google.com/scholar?q=%22Davis%22+intitle:%22A+strategy+for+c...>
  - Bevan, Michelle T. 2001. Modeling and Simulation for Acquisition, Requirements and Training: The Army SMART Model. *The National Summit on U.S. Defense Policy: Acquisition, Research, Test and Evaluation*. IIT – Research Institute. Msiac Retrieved October 24 2007.

**P9) Know the models and simulations used in a given phase of the acquisition process, their inputs and outputs, and their capabilities and limitations.**

- 1) Title: M&S Applications Across the Acquisition Life Cycle
- 2) Module coordinator / point of contact and contact information  
Jim Campbell, GMU, [jcampbell@alionscience.com](mailto:jcampbell@alionscience.com), 703-933-3356
- 3) Module description (short description): At the completion of this module, students will be able to describe the Acquisition life cycle, by phase, using the progression of different modeling and simulation applications in each phase as a benchmark. They will be able to identify a particular tool and apply it appropriately to the correct point in the lifecycle and the proper use of the tool. Taught to the Application Level; for courses at the understanding or general awareness level, time can be reduced and practical application periods deleted.
- 4) ESR supported: P9— Know models and simulations used in a given phase of the acquisition process, their inputs and outputs, and their capabilities and limitations.
- 5) Prerequisites: ACQ 101, ACQ 201, ESR P1 to the application level.
- 6) Module maturity: has it been taught, and if so, a brief history  
An overview of the M&S applications by phase is taught in the one day Acquisition M&S Workshop, but the material is at the understanding level.
- 7) Number of hours: Nine.
- 8) Proposed Delivery: modality face-to-face, or VTC; resident, or customer's site
- 9) Proposed references and texts:
  - a) DoD Directive 5000.1, Defense Acquisition System, 12 May 2003
  - b) DoD Instruction 5000.2, Operation of the Defense Acquisition System, 12 May 2003
  - c) DoD Directive 5000.59, DoD Modeling and Simulation (M&S) Management, 8 August 2007
  - d) Defense Acquisition Guidebook, Version 1.0, 17 October 2004
  - e) CJCSI 3170.01F, Joint Capabilities Integration and Development System, 1 May 2007

- f) CJCSM 3170.01C, Operation of the Joint Capabilities Integration and Development system, 1 May 2007

- 10) Module learning objectives: (and, again, where appropriate their mapping to the project ESRs identified in (4)).
- P9.1: Identify the five phases of the acquisition life cycle.
  - P9.2: Identify the principal M&S applications used in each of the five phases of the acquisition life cycle.
  - P9.3: Describe representative examples of M&S used for each type of application in each phase of the acquisition life cycle.
  - P9.4: List the inputs, outputs, capabilities and limitations of each example M&S.
- 11) Course assessment plan: Examination and practical exercise.
- 12) Topic list by hour of instruction and reference:
- i) Hour one: Introduction and overview (DoDD 5000.1, DoDI 5000.2, CJCSI 3170.01F) P9.1
  - ii) Hour two: M&S in Concept Refinement (course notes and syllabus) P9.2-4
  - iii) Hour three: Technology Development (course notes and syllabus) P9.2-4
  - iv) Hour four: System Development and Demonstration (course notes and syllabus) P9.2-4
  - v) Hour five: Production and Deployment (course notes and syllabus) P9.2-4
  - vi) Hour six: Operations and Support (course notes and syllabus) P9 all
  - vii) Hour seven: Practical application (course notes and syllabus) P9 all
  - viii) Hour eight: Practical application (course notes and syllabus) P9 all
  - ix) Hour nine: Evaluation and Summary (course notes and syllabus) P9 all
- 13) Additional Requirements: N/A.

**P10) Know the common terminology and high level roles and responsibilities, as well as the underlying philosophy, principles, and methodologies used in VV&A efforts, especially those applied in DoD.**

- 1) Title: Verification, Validation, and Accreditation
- 2) Module coordinator / point of contact and contact information  
Jim Campbell, GMU, [jcampbell@alionscience.com](mailto:jcampbell@alionscience.com), 703-933-3356
- 3) Module description: At the completion of this module, students will be able to describe the VV&A process; identify the key players and their roles in the process; explain the importance of the VV&A process; describe key documents and apply VV&A principles to a particular case. Taught to the Application Level; for courses at the understanding or general awareness level, time can be reduced and practical application periods deleted.
- 4) ESR supported: P10—Know the common terminology and high level roles and responsibilities, as well as the underlying philosophy, principles, and methodologies used in VV&A efforts, especially those applied in DoD.
- 5) Prerequisites: M&S overview modules (ESR P1, P2, A1, A2).
- 6) Module maturity: has it been taught, and if so, a brief history  
The current GMU CPE program has eight hours of instruction and has been presented for almost two years. Similar course work has been presented via MSIAC contract to the Navy DACM for one year.
- 7) Number of hours Ten.
- 8) Proposed Delivery: face-to-face, or VTC; resident, or customer's site; on-line
- 9) Proposed references and texts
  - a. DoD Instruction 5000.61, DoD Modeling and Simulation (M&S) Verification, Validation, and Accreditation (VV&A), 13 May 2003
  - b. DA PAM 5-11, Verification, Validation, & Accreditation of Army Models & Simulations, 30 September 1999
  - c. SECNAVINST 5200.40, Verification, Validation, and Accreditation (VV&A) of Models and Simulations, 19 April 1999
  - d. Air Force Instruction 16-1001, Verification, Validation and Accreditation (VV&A) 1 June 1996

- e. Modeling and Simulation Coordination Office (MSCO) Verification, Validation, and Accreditation (VV&A) Recommended Practices Guide – RPG Build 3.0, September 2006
- f. Department of the Navy Modeling and Simulation Verification, Validation and Accreditation Implementation Handbook, Volume I, VV&A Framework, 30 March 2004

10) Module learning objectives:

- P10.1: Define the terms “verification,” “validation,” and “accreditation”
- P10.2: Describe the purpose and expectations of VV&A
- P10.3: Identify the VV&A key players
- P10.4: Describe the VV&A key players roles and responsibilities
- P10.5: Identify the documentation required in the VV&A process
- P10.6: Identify the four categories of VV&A techniques
- P10.7: Describe representative VV&A techniques from each category
- P10.8: List pertinent VV&A references for DOD and representative services

11) Course assessment plan: Examination and practical exercise.

12) Topic list by hour of instruction and reference:

- i) Hour one: Introduction and overview (course notes and syllabus) P10.1-P10.3, P10.8
- ii) Hour two: VV&A Roles and Responsibilities (course notes and syllabus) P10.4
- iii) Hour three: Practical Exercise on VV&A Roles and Responsibilities (course notes and syllabus) P10.4
- iv) Hour four: Practical Exercise on VV&A Roles and Responsibilities (course notes and syllabus) P10.4
- v) Hour five: VV&A Documentation Requirements (course notes and syllabus) P10.5
- vi) Hour six: VV&A Techniques (course notes and syllabus) P10.6, P10.7
- vii) Hour seven: VV&A Techniques (course notes and syllabus) P10.6, P10.7
- viii) Hour eight: Practical Exercise (course notes and syllabus) P10 all
- ix) Hour nine: Practical Exercise (course notes and syllabus) P10 all
- x) Hour ten: Examination and summary (course notes and syllabus) P10all

13) Additional Requirements: This module requires student access to computers and internet connections.

**P11) Be able to correctly match the level of detail of a model with that of the information needed to support a decision, and understand the connection between the decision to be made and the estimation of measures from the model.**

- 1) Module name: Estimation of Measures
- 2) Module coordinator: Marsha Taliaferro-Gillis, Ph.D.  
6596 Main Street  
Gloucester, VA 23061  
(804)694-3173 (Office)  
(804)824-4663 (Cell)  
mtgillis@werneranderson.com
- 3) Module description: Be able to correctly match the level of detail of a model with that of the information needed to support a decision, and understand the connection between the decision to be made and the estimation of measures from the model.
- 4) ESRs that the module supports: P11
- 5) Prerequisites assumed, and corresponding level of mastery:
- 6) Module maturity: none
- 7) Number of hours estimated to teach: 18
- 8) Proposed Delivery modality: face-to-face, on-line, VTC, resident, customer's site
- 9) Proposed references and texts:

Greasley, Andrew. 2004. *Simulation Modeling for Business*. MPG Books Ltd. Great Britain.

Law, Averill M., W. David Kelton. 2000. *Simulation Modeling and Analysis*, 3<sup>rd</sup> ed. McGraw Hill, Boston, MA.

North, Michael J., Charles M. Macal. 2007. *Managing Business Complexity: Discovering Strategic Solutions with Agent- Based Modeling and Simulation* Oxford University Press Inc. New York, NY.

Pooch, Udo W., James A. Wall. 1993. *Discrete Event Simulation a Practical Approach*. CRC Press Inc. Boca Raton, FL.

Rubinstein, Reuven Y., Benjamin Malamed. 1998. *Modern Simulation and Modeling*, John Wiley and Sons, Canada.

Zeigler, Bernard P., Tag Gon Kim, Herbert Praehofer. 2000. *Theory of Modeling and Simulation*. Academic Press. San Diego CA.

10) Module learning objectives:

- P11.1 Define the level of detail, fidelity, aggregation, and disaggregation
- P11.2 Understand intended use and specific use within the context of VV&A
- P11.3 Describe the relationship between simulation level of detail and decision criteria
- P11.4 Group models according to their levels of detail
- P11.5 Given a case study and V&V report, identify the decision criteria that can be supported by M&S
- P11.6 Understand the basic concepts of input and output analysis with respect to a simulations measures of effectiveness
- P11.7 Given a case study, identify if the level of detail in a simulation output matches the decision criteria
- P11.8 Given a case study and sample V&V report assess if modifications of input and output parameters are appropriate for a specific use

11) Course assessment plan: projects, and exams

12) Topic list by hour of instruction and reference.

*Competency Level: General Awareness*

- i) Hour 1: Define the level of detail, fidelity, aggregation, and disaggregation
  - detail
  - fidelity
  - aggregation
  - disaggregation
- Zeigler, Bernard P., Tag Gon Kim, Herbert Praehofer. 2000. *Theory of Modeling and Simulation*. Academic Press. San Diego CA.

*Competency Level: General Awareness*

- ii) Hour 2: Understand the intended use and specific use within the context of VV&A
  - intended and specific use
  - VV&A
- Greasley, Andrew. 2004. *Simulation Modeling for Business*. MPG Books Ltd. Great Britain.
- Pooch, Udo W., James A. Wall. 1993. *Discrete Event Simulation a Practical Approach*. CRC Press Inc. Boca Raton, FL.



*Competency Level: Understanding*

- iii) Hour 3: Understand the intended use and specific use within the context of VV&A
  - intended and specific use
  - VV&A
- Zeigler, Bernard P., Tag Gon Kim, Herbert Praehofer. 2000. *Theory of Modeling and Simulation*. Academic Press. San Diego CA.

*Competency Level: General Awareness*

- iv) Hour 4: Describe the relationship between the simulation level of detail and decision criteria
  - simulation of detail criteria
  - simulation of decision criteria
- Greasley, Andrew. 2004. *Simulation Modeling for Business*. MPG Books Ltd. Great Britain.
- Pooch, Udo W., James A. Wall. 1993. *Discrete Event Simulation a Practical Approach*. CRC Press Inc. Boca Raton, FL.

*Competency Level: Understanding*

- v) Hour 5: Describe the relationship between the simulation level of detail and decision criteria
  - simulation of detail criteria
  - simulation of decision criteria
- Law, Averill M., W. David Kelton. 2000. *Simulation Modeling and Analysis*, 3rd ed. McGraw Hill, Boston, MA.

*Competency Level: Understanding*

- vi) Hour 6: Group models according to their levels of detail.
  - level of detail
- Greasley, Andrew. 2004. *Simulation Modeling for Business*. MPG Books Ltd. Great Britain.
- Pooch, Udo W., James A. Wall. 1993. *Discrete Event Simulation a Practical Approach*. CRC Press Inc. Boca Raton, FL.

*Competency Level: Understanding*

- vii) Hour 7: Given a case study and V&V report, identify the decision criteria that can be supported by M&S
  - case study
  - V&V report
  - decision criteria
  - M&S

- North, Michael J., Charles M. Macal. 2007. *Managing Business Complexity: Discovering Strategic Solutions with Agent- Based Modeling and Simulation*. Oxford University Press Inc. New York, NY.

*Competency Level: Mastery*

- viii) Hour 8: Given a case study and V&V report, identify the decision criteria that can be supported by M&S
  - case study
  - V&V report
  - decision criteria
  - M&S
- North, Michael J., Charles M. Macal. 2007. *Managing Business Complexity: Discovering Strategic Solutions with Agent- Based Modeling and Simulation*. Oxford University Press Inc. New York, NY.

*Competency Level: Mastery*

- ix) Hour 9: Given a case study and V&V report, identify the decision criteria that can be supported by M&S
  - case study
  - V&V report
  - decision Criteria
  - M&S
- North, Michael J., Charles M. Macal. 2007. *Managing Business Complexity: Discovering Strategic Solutions with Agent- Based Modeling and Simulation*. Oxford University Press Inc. New York, NY.

*Competency Level: General Awareness*

- x) Hour 10: Understand the basic concepts of input and output analysis with respect to a simulations measures of effectiveness
  - input and output analysis
  - simulation measures of effectiveness
- Pooch, Udo W., James A. Wall. 1993. *Discrete Event Simulation a Practical Approach*. CRC Press Inc. Boca Raton, FL.

*Competency Level: Understanding*

- xi) Hour 11: Understand the basic concepts of input and output analysis with respect to a simulations measures of effectiveness
  - input and output analysis
  - simulation measures of effectiveness
- Rubinstein, Reuven Y., Bemjamin Malamed. 1998. *Modern Simulation and Modeling*, John Wiley and Sons, Canada.

*Competency Level: Understanding*

- xii) Hour 12: Understand the basic concepts of input and output analysis with respect to a simulations measures of effectiveness
- input and output analysis
  - simulation measures of effectiveness
  - Rubinstein, Reuven Y., Bemjamin Malamed. 1998. *Modern Simulation and Modeling*, John Wiley and Sons, Canada.

*Competency Level: Understanding*

- xiii) Hour 13: Given a case study, identify if the level of detail in a simulation output matches the decision criteria
- case study
  - level of detail in simulation output
  - decision criteria
  - Law, Averill M., W. David Kelton. 2000. *Simulation Modeling and Analysis*, 3rd ed. McGraw Hill, Boston, MA.

*Competency Level: Mastery*

- xiv) Hour 14: Given a case study, identify if the level of detail in a simulation output matches the decision criteria
- case study
  - level of detail in simulation output
  - decision criteria
  - Law, Averill M., W. David Kelton. 2000. *Simulation Modeling and Analysis*, 3rd ed. McGraw Hill, Boston, MA.

*Competency Level: Mastery*

- xv) Hour 15: Given a case study, identify if the level of detail in a simulation output matches the decision criteria
- case study
  - level of detail in simulation output
  - decision criteria
  - Law, Averill M., W. David Kelton. 2000. *Simulation Modeling and Analysis*, 3rd ed. McGraw Hill, Boston, MA.

*Competency Level: Understanding*

- xvi) Hour 16: Given a case study and sample V&V report assess if modifications of input and output parameters are appropriate for a specific use
- case study
  - V&V report
  - input and output parameters
  - Law, Averill M., W. David Kelton. 2000. *Simulation Modeling and Analysis*, 3rd ed. McGraw Hill, Boston, MA.

*Competency Level: Mastery*

- xvii) Hour 17: Given a case study and sample V&V report assess if modifications of input and output parameters are appropriate for a specific use

- case study
- V&V report
- Input and output parameters
- Law, Averill M., W. David Kelton. 2000. *Simulation Modeling and Analysis*, 3rd ed. McGraw Hill, Boston, MA.

*Competency Level: Mastery*

- xviii) Hour 18: Given a case study and sample V&V report assess if modifications of input and output parameters are appropriate for a specific use

- case study
- V&V report
- input and output parameters
- Law, Averill M., W. David Kelton. 2000. *Simulation Modeling and Analysis*, 3rd ed. McGraw Hill, Boston, MA.

**P12) Design a sound simulation study for a given set of objectives.**

- 1) Module name: Simulation Design Study
- 2) Module coordinator/POC: Anthony Genna  
UCSD Extension  
Assistant Director,  
Defense Technology  
agenna@ucsd.edu  
858-603-2170 (cell)
- 3) Module description: Design a sound simulation study for a given set of objectives.
- 4) ESR's that the module supports and the corresponding level of mastery:
- 5) Prerequisites assumed, and corresponding level of mastery: training and education (i.e., BS/MS degree or DAU/DoD courses, certifications, etc.) meeting requirements of current position and/or rank/grade/rate.

In addition it is recommended that students have academic training or OJT equivalent to the following levels of competency:

- (1) M&S "GA" module: General Awareness in current job position
- (2) M&S "UN" module: Understanding in current job position
- (3) M&S "AP" module: Application in current job position
- (4) M&S "MA" module: Mastery in current job position
- 6) Module maturity: has it been taught, and if so, a brief history: TBD
- 7) Number of hours estimated to deliver/teach module: 32 Hours
 

(1) General Awareness	4 hours
(2) Understanding	6 hours
(3) Application	8 hours
(4) Mastery	14 hours
- 9) Proposed Delivery modality:  
- Face-to-face, VTC, resident, customer's site.
- 10) Proposed references and texts:  
Text will be a current, entry-level M&S text to be identified by the instructor at time of delivery. Additional reference material will include current available literature selected by the instructor for practical application in support of the curriculum. Other supporting text/reference material will be student contributions of relevant material from their experience.

DoDD 5000.1 and DoDI 5000.2 : <https://akss.dau.mil/dapc/TUTORIAL/index.htm>

Defense Acquisition Guidebook:

<https://akss.dau.mil/dag/DoD5000.asp?view=document&doc=2>

Defense Acquisition Policy Center: <https://akss.dau.mil/dapc/index.aspx>

Risk Management Guide for DoD Acquisition

<http://www.sei.cmu.edu/risk/dod-risk.pdf>

11.) Module learning objectives: Design a sound simulation study for a given set of objectives.

P12.1	Demonstrate competency level described in above matrix to formulate the problem, set objectives, and conceptualize a simulation model.
P12.2	Demonstrate competency level described in above matrix to identify and collect input data, and design sound model construct - considering simulation alternatives and required complexity.
P12.3	Demonstrate competency level described in above matrix to include verification and validation in the overall simulation study plan. Verification refers to the process of ensuring that the model is free from logical errors - that it does what it is intended to do. Validation is the determination that the model is accurate and ensures representation of the actual system or problem.
P12.4	Demonstrate competency level described in above matrix to estimate measures of performance for the system designs that are being simulated through use of production runs and subsequent analysis.
P12.5	Demonstrate competency level described in above matrix to document and report on program operation, progress, decisions made and achievement of objectives.
P12.6	Demonstrate competency level described in above matrix to create and analyze a sound simulation case study.

12.) Course assessment plan (projects, exams, papers, etc.)

- Team projects/case studies, discussion, written questions.

13) Topic list by hour of instruction and reference:

The hours of instruction are categorized based on the level of competency required. As a result of this format hour structure starts at a level of general awareness and progresses through mastery. This will allow the course material to be easily segmented into each one of the 4 levels of competency.

Hour	Subject Description	Ref:
1-4	Introduction and overview of a simulation study and its relationship to using M&S for acquisition decisions in consideration of a given set of objectives.	Ref [1]
5	Student will demonstrate basic understanding of problem	Ref [1]

Hour	Subject Description	Ref:
	formulation, setting objectives, and conceptualizing a simulation model.	
6	Student will demonstrate basic understanding of identification and collection of input data, and design of sound model construct - considering simulation alternatives and required complexity.	Ref [1]
7	Student will demonstrate basic understanding of the importance of including verification and validation in the overall simulation study plan.	Ref [1]
8-9	Student will demonstrate basic understanding of how to estimate measures of performance for the system designs that are being simulated through use of production runs and subsequent analysis.	Ref [1]
10	Student will demonstrate basic understanding of documenting and reporting on program operation, progress, decisions made and achievement of objectives.	Ref [1]
11	Student will demonstrate ability to use M&S application techniques for problem formulation, setting objectives, and conceptualizing a simulation model.	Ref [1]
12	Student will demonstrate ability to use M&S application techniques in identification and collection of input data, and design of sound model construct - considering simulation alternatives and required complexity.	Ref [1]
13	Student will demonstrate ability to use M&S application techniques relating to the importance of including verification and validation in the overall simulation study plan.	Ref [1]
14-16	Student will demonstrate ability to use M&S application techniques for estimating and obtaining measures of performance for the system designs that are being simulated through use of production runs and subsequent analysis.	Ref [1]
17-18	Student will demonstrate ability to use M&S application techniques for assessing, documenting and reporting on program operation, progress, decisions made and achievement of objectives.	Ref [1]
19	Student will demonstrate use of M&S tools in support of problem formulation, setting objectives, and conceptualizing and selecting a simulation model.	Ref [1]
20	Student will demonstrate use of M&S tools to support design of sound model construct - considering appropriate input, simulation alternatives and required complexity.	Ref [1]
21	Student will apply knowledge of M&S tools to support analysis and evaluation of verification and validation in the overall simulation study plan.	Ref [1]
22-24	Student will apply knowledge of M&S tools in support of evaluating production runs and subsequent analysis to obtain measures of performance for the system designs that are being simulated. Includes case studies.	Ref [1]

Hour	Subject Description	Ref:
25-27	Class project: Student will create a sound simulation case study, by applying principles of previous course hours.	Ref [1]
28	Student will demonstrate use of M&S tools in support of assessing, documenting and reporting on program operation, progress, decisions made and achievement of objectives.	Ref [1]
29-32	Class project: Student will demonstrate use of M&S tools to perform analysis and evaluation of a sound simulation case study.	Ref [1]

Ref [1] TBD by NPS partners.



**P13) Use appropriate statistical techniques for the analysis of simulation output.**

- 1) Module name: Appropriate Statistical Technique
- 2) Module coordinator: Marsha Taliaferro-Gillis, Ph.D.  
6596 Main Street  
Gloucester, VA 23061  
(804)694-3173 (Office)  
(804)824-4663 (Cell)  
mtgillis@werneranderson.com
- 3) Module description: Use appropriate statistical techniques for the analysis of simulation output.
- 4) ESRs that the Module supports and corresponding level of mastery. P13
- 5) Prerequisites assumed, and corresponding level of mastery:
- 6) Module maturity: none
- 7) Number of hours estimated to teach 38
- 8) Proposed Delivery modality: face-to-face, on-line, VTC, resident, customer's site
- 9) Proposed references and texts:

Averill, M. Law, W. David, Kelton. 2000. *Simulation Modeling and Analysis..* The McGraw Hill Companies, Boston.

Box, George E.P., William G., Hunter, J. Stuart, Hunter. 1978. *Statistics for Experimenters; An Introduction to Design, Data Analysis, and Model Building*, John Wiley & Sons, New York.

Guttman, Irwin, S, S, Wilks, J. Stuart, Hunter. 1982. *Introductory Engineering Statistics*. John Wiley & Sons, Inc., Canada.

Rubenstein, Reuven Y., Benjamin, Melamel. 1998. *Modern Simulation and Modeling*. John Wiley & Sons, Inc., 605 Third Avenue, New York, NY.

Johnson, J.A.,D.W., Wichern. 1992. *Applied Multivariate Statistical Analysis*, Prentice-Hall, Inc., Upper Saddle River, NJ, USA

Sargeant, Robert G. 1976. Statistical Analysis of Simulation Output Data. Simulation of Computer Networks, Proceedings of the 4<sup>th</sup> Symposium on Simulation of Computer Systems, Boulder, Colorado. ACM Special Interest Group on

Simulation and Modeling. The ACM Digital Library, IEEE Press, Piscataway, NJ, USA.

10) Module learning objectives:

- P13.1 Understand transient and steady-state behavior of stochastic processes
- P13.2 Apply statistical analysis for terminating simulations
- P13.3 Apply statistical analysis for steady state parameters
- P13.4 Apply statistical analysis for steady-state cycle parameters
- P13.5 Apply methods for evaluating multiple measures of performance
- P13.6 Apply plotting methods for analyzing data
- P13.7 Apply hypothesis testing, ANOVA, and confidence intervals
- P13.8 Apply methods for comparing multiple alternatives (e.g. ranking and selection)
- P13.9 Understand the generation of random variates in computers and apply variance reduction techniques
- P13.10 Understand experimental design and optimization and apply sensitivity analysis

11) Module assessment plan: projects, and exams

12) Topic list by hour of instruction and reference.

*Competency Level: General Awareness*

- i) Hour 1: Understand transient and steady-state behavior of stochastic processes
  - stochastic processes
  - transient and steady-state behaviors
  - Averill, M. Law, W. David, Kelton. 2000. *Simulation Modeling and Analysis, Chapter 9*. The McGraw Hill Companies, Boston.
  - Rubenstein, Reuven Y., Benjamin, Melamel. 1998. *Modern Simulation and Modeling, Chapter 2*. John Wiley & Sons, Inc. 605 Third Avenue, New York

*Competency Level: Understanding*

- ii) Hour 2: Understand transient and steady-state behavior of stochastic processes
  - stochastic processes
  - transient and steady-state behaviors
  - Averill, M. Law, W. David, Kelton, 2000. *Simulation Modeling and Analysis; Chapter 9*, The McGraw Hill Companies, Boston.
  - Rubenstein, Reuven Y., Benjamin, Melamel. 1998. *Modern Simulation and Modeling; Chapter 2*, John Wiley & Sons, Inc. 605 Third Avenue, New York, N

*Competency Level: Understanding*

iii) Hour 3: Understand transient and steady-state behavior of stochastic processes

- stochastic processes
- transient and steady-state processes
- Averill, M. Law, W. David, Kelton. 2000. *Simulation Modeling and Analysis, Chapter 9*. The McGraw Hill Companies, Boston.
- Rubenstein, Reuven Y., Benjamin, Melamel, 1998. *Modern Simulation and Modeling, Chapter 2*. John Wiley & Sons, Inc. 605 Third Avenue, New York, NY

*Competency Level: Understanding*

iv) Hour 4: Understand transient and steady-state behavior of stochastic processes

- stochastic processes
- transient and steady-state processes
- Averill, M. Law, W. David, Kelton, 2000. *Simulation Modeling and Analysis, Chapter 9*. The McGraw Hill Companies, Boston.
- Rubenstein, Reuven Y., Benjamin, Melamel, 1998. *Modern Simulation and Modeling, Chapter 2*. John Wiley & Sons, Inc. 605 Third Avenue, New York, NY.

*Competency Level: General Awareness*

iii) Hour 5: Apply statistical analysis for terminating simulations

- statistical analysis
- terminating simulations
- Averill, M. Law and Kelton, W. David, 2000. *Simulation Modeling and Analysis, Chapter 9*, The McGraw Hill Companies, Boston.

*Competency Level: Understanding*

iv) Hour 6: Apply statistical analysis for terminating simulations

- statistical analysis
- terminating simulations
- Averill, M. Law, W. David, Kelton. 2000. *Simulation Modeling and Analysis, Chapter 9*. The McGraw Hill Companies, Boston.

*Competency Level: Application*

v) Hour 7: Apply statistical analysis for terminating simulations

- statistical analysis
- terminating simulations

- Averill, M. Law, W. David, Kelton. 2000. *Simulation Modeling and Analysis, Chapter 9*. The McGraw Hill Companies, Boston.

*Competency Level: Application*

- vi) Hour 8: Apply statistical analysis for terminating simulations
  - statistical analysis
  - terminating simulations
- Averill, M. Law, W. David, Kelton. 2000. *Simulation Modeling and Analysis, Chapter 9*. The McGraw Hill Companies, Boston.

*Competency Level: General Awareness*

- vii) Hour 9: Apply statistical analysis for steady-state parameters
  - statistical analysis
  - steady-state parameters
- Averill, M. Law, W. David, Kelton 2000. *Simulation Modeling, and Analysis, Chapter 9.5*. The McGraw Hill Companies, Boston.

*Competency Level: Understanding*

- viii) Hour 10: Apply statistical analysis for steady state parameters
  - statistical analysis
  - steady-state parameters
- Averill, M. Law, W. David, Kelton. 2000. *Simulation Modeling and Analysis, Chapter 9.5*. The McGraw Hill Companies, Boston.

*Competency Level: Application*

- ix) Hour 11: Apply statistical analysis for steady state parameters
  - statistical analysis
  - steady-state parameters
- Averill, M. Law, W. David, Kelton, 2000. *Simulation Modeling and Analysis, Chapter 9.5*. The McGraw Hill Companies, Boston.

*Competency Level: Application*

- x) Hour 12: Apply statistical analysis for steady state parameters
  - statistical analysis
  - steady-state parameters
- Averill, M. Law, W. David, Kelton. 2000. *Simulation Modeling and Analysis, Chapter 9.5*. The McGraw Hill Companies, Boston.

*Competency Level: General Understanding*

- xi) Hour 13: Apply statistical analysis for steady-state cycle parameters

- statistical analysis
- steady-state parameters
- Averill, M. Law, W. David, Kelton. 2000. *Simulation Modeling and Analysis, Chapter 9.5*. The McGraw Hill Companies, Boston.

*Competency Level: Understanding*

- xii) Hour 14: Apply statistical analysis for steady-state cycle parameters
- statistical analysis
  - steady-state parameters
  - Averill, M. Law, W. David, Kelton. 2000. *Simulation Modeling and Analysis, Chapter 9.5*. The McGraw Hill Companies, Boston.

*Competency Level: Application*

- xiii) Hour 15: Apply statistical analysis for steady-state cycle parameter
- statistical analysis
  - steady-state parameters
  - Averill, M. Law, W. David, Kelton. 2000. *Simulation Modeling and Analysis, Chapter 9.6*. The McGraw Hill Companies, Boston.

*Competency Level: Application*

- xiv) Hour 16: Apply statistical analysis for steady-state cycle parameters
- statistical analysis
  - steady-state parameter
  - Averill, M. Law, W. David, Kelton. 2000. *Simulation Modeling and Analysis, Chapter 9.6*. The McGraw Hill Companies, Boston.

*Competency Level: General Awareness*

- xv) Hour 17: Apply methods for evaluating multiple measures of performance
- evaluating multiple measures
  - Johnson, J.A., D. W., Wichern. 1992. *Applied Multivariate Statistical Analysis*. Prentice-Hall, Inc., Upper Saddle River, NJ, USA

*Competency Level: Understanding*

- xvi) Hour 18: Apply methods for evaluating multiple measures of performance
- evaluating multiple measures
  - Johnson, J.A., D. W., Wichern. 1992. *Applied Multivariate Statistical Analysis*. Prentice-Hall, Inc., Upper Saddle River, NJ, USA

*Competency Level: Application*

- xvii) Hour 19: Apply methods for evaluating multiple measures of performance
- evaluating multiple measures
  - Johnson, J.A., D, W., Wichern. 1992. *Applied Multivariate Statistical Analysis*. Prentice-Hall, Inc., Upper Saddle River, NJ, USA

*Competency Level: Application*

- xviii) Hour 20: Apply plotting methods for analyzing data
- plotting data
  - analyzing data
  - Box, George, E.P., William G., Hunter, J. Stuart, Hunter. 1978. *Statistics for Experimenters; An Introduction to Design, Data Analysis, and Model Building*, John Wiley & Sons, New York.

*Competency Level: Application*

- xix) Hour 21: Apply plotting methods for analyzing data
- plotting data
  - analyzing data
  - Box, George E.P., William G., Hunter, J. Stuart, Hunter. 1978. *Statistics for Experimenters; An Introduction to Design, Data Analysis, and Model Building*, John Wiley & Sons, New York.

*Competency Level: General Awareness*

- xx) Hour 22: Apply hypothesis testing, ANOVA, and confidence intervals
- hypothesis testing
  - ANOVA
  - confidence intervals
  - Averill, M. Law, W. David, Kelton. 2000. *Simulation Modeling and Analysis..* The McGraw Hill Companies, Boston.
  - Box, George E.P., William G., Hunter, J. Stuart, Hunter. 1978. *Statistics for Experimenters; An Introduction to Design, Data Analysis, and Model Building*, John Wiley & Sons, New York.
  - Guttman, Irwin, S, S, Wilks, J. Stuart, Hunter. 1982. *Introductory Engineering Statistics*. John Wiley & Sons, Inc., Canada.
  - Sargeant, Robert G. 1976. Statistical Analysis of Simulation Output Data. Simulation of Computer Networks, Proceedings of the 4<sup>th</sup> Symposium on Simulation of Computer Systems, Boulder, Colorado. ACM Special Interest Group on Simulation and Modeling, The ACM Digital Library, IEEE Press, Piscataway, NJ, USA.

*Competency Level: Understanding*

- xxi) Hour 23: Apply hypothesis testing, ANOVA, and confidence intervals
- hypothesis testing
  - ANOVA
  - confidence intervals
  - Averill, M. Law, W. David, Kelton. 2000. *Simulation Modeling and Analysis*. The McGraw Hill Companies, Boston.
  - Box, George E.P., William G., Hunter, J. Stuart, Hunter. 1978. *Statistics for Experimenters; An Introduction to Design, Data Analysis, and Model Building*, John Wiley & Sons, New York.
  - Guttman, Irwin, S, S, Wilks, J. Stuart, Hunter. 1982. *Introductory Engineering Statistics*. John Wiley & Sons, Inc., Canada.
  - Sargeant, Robert G. 1976. Statistical Analysis of Simulation Output Data. Simulation of Computer Networks, Proceedings of the 4<sup>th</sup> Symposium on Simulation of Computer Systems, Boulder, Colorado. ACM Special Interest Group on Simulation and Modeling, The ACM Digital Library, IEEE Press, Piscataway, NJ, USA.

*Competency Level: Application*

- xxii) Hour 24: Apply hypothesis testing, ANOVA, and confidence intervals
- hypothesis testing
  - ANOVA
  - confidence intervals
  - Averill, M. Law, W. David, Kelton. 2000. *Simulation Modeling and Analysis, chapter10*. The McGraw Hill Companies, Boston.
  - Box, George E.P., William G., Hunter, J. Stuart, Hunter. 1978. *Statistics for Experimenters; An Introduction to Design, Data Analysis, and Model Building, Chapters 6-6*. John Wiley & Sons, New York.
  - Guttman, Irwin, S, S, Wilks, J. Stuart, Hunter. 1982. *Introductory Engineering Statistics, Chapters 10-16, Chart VIII*. John Wiley & Sons, Inc., Canada.
  - Sargeant, Robert G. 1976. Statistical Analysis of Simulation Output Data. Simulation of Computer Networks, Proceedings of the 4<sup>th</sup> Symposium on Simulation of Computer Systems, Boulder, Colorado. ACM Special Interest Group on Simulation and

*Competency Level: Application*

- xxiii) Hour 25: Apply hypothesis testing, ANOVA, and confidence intervals
- hypothesis testing
  - ANOVA confidence intervals
  - Averill, M. Law, W. David, Kelton. 2000. *Simulation Modeling and Analysis, chapter10*. The McGraw Hill Companies, Boston.

- Box, George E.P., William G., Hunter, J. Stuart, Hunter. 1978. *Statistics for Experimenters; An Introduction to Design, Data Analysis, and Model Building, Chapters 6-6*. John Wiley & Sons, New York.
- Guttman, Irwin, S, S, Wilks, J. Stuart, Hunter. 1982. *Introductory Engineering Statistics, Chapters 10-16, Chart VIII*. John Wiley & Sons, Inc., Canada.
- Sargeant, Robert G. 1976. Statistical Analysis of Simulation Output Data. Simulation of Computer Networks, Proceedings of the 4<sup>th</sup> Symposium on Simulation of Computer Systems, Boulder, Colorado. ACM Special Interest Group on Simulation and

*Competency Level: Application*

- xxiv) Hour 26: Apply hypothesis testing, ANOVA, and confidence intervals
- hypothesis testing
  - ANOVA
  - confidence levels
- Averill, M. Law, W. David, Kelton. 2000. *Simulation Modeling and Analysis, chapter10*. The McGraw Hill Companies, Boston.
  - Box, George E.P., William G., Hunter, J. Stuart, Hunter. 1978. *Statistics for Experimenters; An Introduction to Design, Data Analysis, and Model Building, Chapters 6-6*. John Wiley & Sons, New York.
  - Guttman, Irwin, S, S, Wilks, J. Stuart, Hunter. 1982. *Introductory Engineering Statistics, Chapters 10-16, Chart VIII*. John Wiley & Sons, Inc., Canada.
  - Sargeant, Robert G. 1976. Statistical Analysis of Simulation Output Data. Simulation of Computer Networks, Proceedings of the 4<sup>th</sup> Symposium on Simulation of Computer Systems, Boulder, Colorado. ACM Special Interest Group on Simulation and

*Competency Level: General Awareness*

- xxv) Hour 27: Apply methods for comparing multiple alternatives (e.g. ranking and selection)
- ranking
  - selection
  - multiple alternatives
- Averill, M. Law, W. David, Kelton. 2000. *Simulation Modeling and Analysis, chapter10*. The McGraw Hill Companies, Boston.



*Competency Level: Understanding*

xxvi) Hour 28: Apply methods for comparing multiple alternatives (e.g. ranking and selection)

- ranking
- selection
- multiple alternatives
- Averill, M. Law, W. David, Kelton. 2000. *Simulation Modeling and Analysis, chapter10*. The McGraw Hill Companies, Boston.

*Competency Level: Application*

xxvii) Hour 29: Apply methods for comparing multiple alternatives (e.g. ranking and selection)

- ranking
- selection
- multiple alternatives
- Averill, M. Law, W. David, Kelton. 2000. *Simulation Modeling and Analysis, chapter10*. The McGraw Hill Companies, Boston.

*Competency Level: General Awareness*

xxviii) Hour 30: Understand the generation of random variates in computers and apply variance reduction techniques

- random variates
- variance reduction
- Averill, M. Law, W. David, Kelton. 2000. *Simulation Modeling and Analysis, chapter10*. The McGraw Hill Companies, Boston.
- Rubenstein, Reuven Y., Benjamin, Melamel. 1998. *Modern Simulation and Modeling, Chapter 4*. John Wiley & Sons, Inc. 605 Third Avenue, New York, NY.

*Competency Level: Understanding*

xxix) Hour 31: Understand the generation of random variates in computers and apply variance reduction techniques

- random variates
- variance reduction
- Averill, M. Law, W. David, Kelton. 2000. *Simulation Modeling and Analysis, chapter10*. The McGraw Hill Companies, Boston.
- Rubenstein, Reuven Y., Benjamin, Melamel. 1998. *Modern Simulation and Modeling, Chapter 4*. John Wiley & Sons, Inc. 605 Third Avenue, New York, NY.

*Competency Level: Understanding*

- xxx) Hour 32 Understand the generation of random variates in computers and apply variance reduction techniques
- random variates
  - variance reduction
  - Averill, M. Law, W. David, Kelton. 2000. *Simulation Modeling and Analysis, chapter10*. The McGraw Hill Companies, Boston.
  - Rubenstein, Reuven Y., Benjamen, Melamel. 1998. *Modern Simulation and Modeling, Chapter 4*. John Wiley & Sons, Inc. 605 Third Avenue, New York, NY.

*Competency Level: Application*

- xxxii) Hour 33: Understand the generation of random variates in computers and apply variance reduction techniques
- random variates
  - variance reduction
  - Averill, M. Law, W. David, Kelton. 2000. *Simulation Modeling and Analysis, chapter10*. The McGraw Hill Companies, Boston.
  - Rubenstein, Reuven Y., Benjamen, Melamel. 1998. *Modern Simulation and Modeling, Chapter 4*. John Wiley & Sons, Inc. 605 Third Avenue, New York, NY.

*Competency Level: General Awareness*

- xxxiii) Hour 34: Understand experimental design and optimization and apply sensitivity analysis
- experimental design
  - optimization
  - sensitivity analysis
  - Averill, M. Law, W. David, Kelton. 2000. *Simulation Modeling and Analysis, chapter10*. The McGraw Hill Companies, Boston.
  - Rubenstein, Reuven Y., Benjamen, Melamel. 1998. *Modern Simulation and Modeling, Chapter 4*. John Wiley & Sons, Inc. 605 Third Avenue, New York, NY.

*Competency Level: Understanding*

- xxxiiii) Hour 35: Understand experimental design and optimization and apply sensitivity analysis
- experimental design
  - optimization
  - sensitivity analysis
  - Averill, M. Law, W. David, Kelton. 2000. *Simulation Modeling and Analysis, chapter10*. The McGraw Hill Companies, Boston.

- Rubenstein, Reuven Y., Benjamin, Melamel. 1998. *Modern Simulation and Modeling, Chapter 4*. John Wiley & Sons, Inc. 605 Third Avenue, New York, NY.

*Competency Level: Understanding*

xxxiv) Hour 36: Understand experimental design and optimization and apply sensitivity analysis

- experimental design
- optimization
- sensitivity analysis
- Averill, M. Law, W. David, Kelton. 2000. *Simulation Modeling and Analysis, chapter10*. The McGraw Hill Companies, Boston.
- Rubenstein, Reuven Y., Benjamin, Melamel. 1998. *Modern Simulation and Modeling, Chapter 4*. John Wiley & Sons, Inc. 605 Third Avenue, New York, NY.

*Competency Level: Understanding*

xxxv) Hour 37: Understand experimental design and optimization and apply sensitivity analysis

- experimental design
- optimization
- sensitivity analysis
- Averill, M. Law, W. David, Kelton. 2000. *Simulation Modeling and Analysis, chapter10*. The McGraw Hill Companies, Boston.
- Rubenstein, Reuven Y., Benjamin, Melamel. 1998. *Modern Simulation and Modeling, Chapter 4*. John Wiley & Sons, Inc. 605 Third Avenue, New York, NY.

*Competency Level: Mastery*

xxviii) Hour 38: Understand experimental design and optimization and apply sensitivity analysis

- experimental design
- optimization
- sensitivity analysis
- Averill, M. Law, W. David, Kelton. 2000. *Simulation Modeling and Analysis, chapter10*. The McGraw Hill Companies, Boston.
- Rubenstein, Reuven Y., Benjamin, Melamel. 1998. *Modern Simulation and Modeling, Chapter 4*. John Wiley & Sons, Inc. 605 Third Avenue, New York, NY.

**P14) Manage and reuse existing models, data, and simulations appropriately and assure that new products developed are designed and prepared for reuse.**

- 1) Module name: Manage and Reuse
- 2) Module coordinator: Marsha Taliaferro-Gillis, Ph.D.  
6596 Main Street  
Gloucester, VA 23061  
(804)694-3173 (Office)  
(804)824-4663 (Cell)  
mtgillis@werneranderson.com
- 3) Module description: Manage and reuse existing models, data, and simulations appropriately and assure that new products developed are designed and prepared for reuse.
- 4) ESRs that the module supports: P14
- 5) Prerequisites assumed, and corresponding level of mastery:
- 6) Module maturity: none
- 7) Number of hours estimated to teach: 18
- 8) Proposed Delivery modality: face-to-face, on-line, VTC, resident, customer's site
- 9) Proposed references and texts:

Pastor, Oscar. Juan Carlos Molina. 1998, *Model-Driven Architecture in Practice: A Software Production Environment on Conceptual Modeling*. Springer-Verlag. Berlin, Heidelberg.

Rombach, H. D., Victor R. Basili, Richard W. Selby. 1993 *Experimental Software Engineering Issues*. Springer-Verlag. Berlin, Heidelberg.

Zeigler, Bernard P., Tag Gon Kim, Herbert Praehofer. 2000. *Theory of Modeling and Simulation*. Academic Press. San Diego CA.

- 10) Module learning objectives:
  - P14.1 Understand key concepts for M&S reuse, component-based, and distributed simulations
  - P14.2 Identify characteristics of new simulation development that make reuse more achievable
  - P14.3 Identify sources for models that are available for reuse
  - P14.4 Analyze cost versus benefit for reuse of legacy simulations

- P14.5 Describe V&V necessary for reuse of a simulation considering a new specific use
- P14.6 Given a case study and a sample of VV&A report, identify appropriate models for reuse from a set of legacy models
- P14.7 Given a case study and a sample of VV&A report, determine the most cost effective option considering reuse of legacy simulations and new simulation development

11) Course assessment plan: projects, and exams

12) Topic list by hour of instruction and reference.

*Competency Level: General Awareness*

- i) Hour 1: Understand key concepts for M&S reuse, component-based, and distributed simulations
  - M&S reuse
  - component- based simulations
  - distributed simulations
- Rombach, H. D., Victor R. Basili, Richard W. Selby. 1993  
*Experimental Software Engineering Issues*. Springer-Verlag. Berlin, Heidelberg.

*Competency Level: Understanding*

- ii) Hour 2: Understand key concepts for M&S reuse, component-based, and distributed simulations
  - M&S reuse
  - component- based simulations
  - distributed simulations
- Rombach, H. D., Victor R. Basili, Richard W. Selby. 1993  
*Experimental Software Engineering Issues*. Springer-Verlag. Berlin, Heidelberg.

*Competency Level: Understanding*

- iii) Hour 3: Understand key concepts for M&S reuse, component-based, and distributed simulations
  - M&S reuse
  - component- based simulations
  - distributed simulations

*Competency Level: General Awareness*

- iv) Hour 4: Identify characteristics of new simulation development that make reuse more achievable
  - new simulation development
  - reuse

*Competency Level: General Awareness*

- v) Hour5: Identify characteristics of new simulation development that make reuse more achievable
  - new simulation development
  - reuse

*Competency Level: General Awareness*

- vi) Hour 6: Identify sources for models that are available for reuse

*Competency Level: Understanding*

- vii) Hour 7: Analyze cost versus benefit for reuse of legacy simulations
  - cost versus benefit
  - reuse
  - legacy simulations
- Pastor, Oscar. Juan Carlos Molina. 1998, *Model-Driven Architecture in Practice: A Software Production Environment on Conceptual Modeling*. Springer-Verlag. Berlin, Heidelberg.

*Competency Level: Mastery*

- viii) Hour8: Analyze cost versus benefit for reuse of legacy simulations
  - cost versus benefit
  - reuse
  - legacy simulations
- Pastor, Oscar. Juan Carlos Molina. 1998, *Model-Driven Architecture in Practice: A Software Production Environment on Conceptual Modeling*. Springer-Verlag. Berlin, Heidelberg.

*Competency Level: Mastery*

- ix) Hour 9: Analyze cost versus benefit for reuse of legacy simulations
  - cost versus benefit
  - reuse
  - legacy simulations

*Competency Level: General Awareness*

- x) Hour 10: Describe V&V necessary for reuse of a simulation considering a new specific use
  - V&V
  - reuse
  - new specific use

*Competency Level: Understanding*

- xi) Hour 11: Describe V&V necessary for reuse of a simulation considering a new specific use
  - V&V
  - reuse

- new specific use

*Competency Level: Understanding*

- xii) Hour 12: Describe V&V necessary for reuse of a simulation considering a new specific use
- V&V
  - reuse
  - new specific use

*Competency Level: Understanding*

- xiii) Hour 13: Given a case study and a sample of VV&A report, identify appropriate models for reuse from a set of legacy models
- case study
  - VV&A report
  - models for reuse
  - legacy models

*Competency Level: Mastery*

- xiv) Hour 14: Given a case study and a sample of VV&A report, identify appropriate models for reuse from a set of legacy models
- case study
  - VV&A report
  - models for reuse
  - legacy models

*Competency Level: Mastery*

- xv) Hour 15: Given a case study and a sample of VV&A report, identify appropriate models for reuse from a set of legacy models
- case study
  - VV&A report
  - models for reuse
  - legacy models

*Competency Level: Understanding*

- xvi) Hour 16: Given a case study and a sample of VV&A report, determine the most cost effective option considering reuse of legacy simulations and new simulation development
- case study
  - VV&A report
  - cost
  - reuse
  - legacy simulations
  - new simulation development
- Zeigler, Bernard P., Tag Gon Kim, Herbert Praehofer. 2000. *Theory of Modeling and Simulation*. Academic Press. San Diego CA.

*Competency Level: Mastery*

xvii) Hour 17: Given a case study and a sample of VV&A report, determine the most cost effective option considering reuse of legacy simulations and new simulation development

- case study
- VV&A report
- cost
- reuse
- legacy simulations
- new simulation development

*Competency Level: Mastery*

xviii) Hour 18: . Given a case study and a sample of VV&A report, determine the most cost effective option considering reuse of legacy simulations and new simulation development

- case study
- VV&A report
- cost
- reuse
- legacy simulations
- new simulation development

---

1) Module name P14-G Reuse of models, data, and simulations (General awareness)

2) Coordinator

Dr. Mikel D. Petty, UAH CMSA, 256-824-4368, pettym@uah.edu

3) Module description This module comprises topics to provide training to a “General awareness” level of competence for program managers, systems engineers, and test and evaluation workforce members for ESR P14: Manage and reuse existing models, data, and simulations appropriately and assure that new products developed are designed and prepared for reuse.

4) ESRs that the module supports and the corresponding level of competence  
P14 General awareness

5) Prerequisites assumed and the corresponding level of competence Basic familiarity with M&S concepts, equivalent to MSIAC M&S Staff Officers Course

6) Module maturity Portions of the material have been taught by the module coordinator in both Old Dominion University’s MSIM 601 course and in Certified Modeling and Simulation Professional examination preparation courses.

7) Number of hours estimated to deliver/teach module 12



8) Proposed delivery modalities Face-to-face lecture, synchronous distance learning (live audio/video connection), asynchronous distance learning (web or CD).

9) Proposed references and texts (topics refer to these by number)

[1] P. K. Davis and R. H. Anderson, *Improving the Composability of Department of Defense Models and Simulations*, RAND National Defense Research Institute, Santa Monica CA, 2003.

[2] E. W. Weisel, M. D. Petty, and R. R. Mielke, "A Survey of Engineering Approaches to Composability", *Proceedings of the Spring 2004 Simulation Interoperability Workshop*, Arlington VA, April 18-23 2004, pp. 722-731.

[3] W. Royce, "The COCOMO Cost Estimation Model", in W. Royce, *Software Project Management*, Addison-Wesley, Reading MA, 1998, pp. 265-281.

10) Module learning objectives Correspond to sub-ESRs for ESR P14

- a) P14.1 Define the different methods by which a model or simulation can be reused.
- b) P14.2 Given a model and a proposed reuse application for it, identify suitable methods to implement the reuse.
- c) P14.3 Determine the level of effort required to reuse a model, data set, or simulation in various applications under different reuse methods. Calculate the incremental level of effort required to make a model, data set, or simulation reusable.
- d) P14.4 Classify proposed reuse applications of a model, data set, or simulation as appropriate or inappropriate based on modeling paradigm, level of resolution, and bounds of validity.
- e) P14.5 Identify the assumptions behind a model, data set, or simulation, and determine how those assumptions constrain appropriate reuse applications.
- f) P14.6 List current simulation interoperability protocol standards, interoperability frameworks and middleware libraries, and composability approaches that support reuse, and describe the advantages and disadvantages of each.
- g) P14.7 List existing resources available for reuse, including model repositories, implemented federations, standalone simulations, standard object models, and accredited data sets, and describe the procedures for searching for resources within repositories of them.
- h) P14.8 Identify measures in new simulation development that will encourage reuse or make reuse more cost effective.
- i) P14.9 Identify the levels of conceptual interoperability possible between interoperable simulations, and describe the extent of functionality and reusability associated with each level.
- j) P14.10 Describe case studies of successful reuse applications of commonly used models, data sets, and simulations, and the characteristics of those applications that made the reuse successful.
- k) P14.11 Given a case study, analyze cost vs benefit for reuse of a legacy simulation.
- l) P14.12 Given a case study, analyze the additional V&V effort necessary for reuse of a legacy simulation for a new use that may differ from past uses.

11) Course assessment plan End of module examination

12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any):

1. Basic concepts, definitions, and examples of reuse methods; P14.1; [1] [2]
2. Basic concepts, definitions, and examples of reuse applications; P14.2; [1] [2]
3. Basic concepts, definitions, and examples of level of effort associated with reuse; P14.3; [1] [2]
4. Basic concepts, definitions, and examples of reuse-determining concepts (modeling paradigm, level of resolution, bounds of validity); P14.4; [1] [2]
5. Basic concepts, definitions, and examples of assumptions in models, data sets, and simulations; P14.5; to be determined
6. Basic concepts, definitions, and examples of different types of reuse technologies (interoperability protocol standards, interoperability frameworks and middleware layers, composability approaches); P14.6; [1] [2]
7. Basic concepts, definitions, and examples of each type of existing reuse resource; P14.7; [1]
8. Basic concepts, definitions, and examples of reuse measures; P14.8; [1]
9. Basic concepts, definitions, and examples of levels of conceptual interoperability; P14.9; to be determined
10. Simple case studies of successful reuse in test and acquisition M&S applications; P14.10; to be determined
11. Basic concepts, definitions, and examples of reuse cost versus benefit in legacy simulations; P14.11; [1]
12. Basic concepts, definitions, and examples of verification and validation effort when reusing legacy simulations; P14.12; [1]

1) Module name P14-U Reuse of models, data, and simulations (Understanding)

2) Coordinator

Dr. Mikel D. Petty, UAH CMSA, 256-824-4368, pettym@uah.edu

3) Module description This module comprises topics to provide training to a “Understanding” level of competence for program managers, systems engineers, and test and evaluation workforce members for ESR P14: Manage and reuse existing models, data, and simulations appropriately and assure that new products developed are designed and prepared for reuse.

4) ESRs that the module supports and the corresponding level of competence  
P14 Understanding

5) Prerequisites assumed and the corresponding level of competence Module P14-G

- 6) Module maturity: Portions of the material have been taught by the module coordinator in both Old Dominion University's MSIM 601 course and in Certified Modeling and Simulation Professional examination preparation courses
- 7) Number of hours estimated to deliver/teach module 18
- 8) Proposed delivery modalities Face-to-face lecture, synchronous distance learning (live audio/video connection), asynchronous distance learning (web or CD)
- 9) Proposed references and texts (topics refer to these by number)
  - [1] P. K. Davis and R. H. Anderson, *Improving the Composability of Department of Defense Models and Simulations*, RAND National Defense Research Institute, Santa Monica CA, 2003.
  - [2] E. W. Weisel, M. D. Petty, and R. R. Mielke, "A Survey of Engineering Approaches to Composability", *Proceedings of the Spring 2004 Simulation Interoperability Workshop*, Arlington VA, April 18-23 2004, pp. 722-731.
  - [3] W. Royce, "The COCOMO Cost Estimation Model", in W. Royce, *Software Project Management*, Addison-Wesley, Reading MA, 1998, pp. 265-281.
- 10) Module learning objectives Correspond to sub-ESRs for ESR P14
  - a) P14.1 Define the different methods by which a model or simulation can be reused.
  - b) P14.2 Given a model and a proposed reuse application for it, identify suitable methods to implement the reuse.
  - c) P14.3 Determine the level of effort required to reuse a model, data set, or simulation in various applications under different reuse methods. Calculate the incremental level of effort required to make a model, data set, or simulation reusable.
  - d) P14.4 Classify proposed reuse applications of a model, data set, or simulation as appropriate or inappropriate based on modeling paradigm, level of resolution, and bounds of validity.
  - e) P14.5 Identify the assumptions behind a model, data set, or simulation, and determine how those assumptions constrain appropriate reuse applications.
  - f) P14.6 List current simulation interoperability protocol standards, interoperability frameworks and middleware libraries, and composability approaches that support reuse, and describe the advantages and disadvantages of each.
  - g) P14.7 List existing resources available for reuse, including model repositories, implemented federations, standalone simulations, standard object models, and accredited data sets, and describe the procedures for searching for resources within repositories of them.
  - h) P14.8 Identify measures in new simulation development that will encourage reuse or make reuse more cost effective.
  - i) P14.9 Identify the levels of conceptual interoperability possible between interoperable simulations, and describe the extent of functionality and reusability associated with each level.
  - j) P14.10 Describe case studies of successful reuse applications of commonly used models, data sets, and simulations, and the characteristics of those applications that made the reuse successful.

- k) P14.11 Given a case study, analyze cost vs benefit for reuse of a legacy simulation.
- l) P14.12 Given a case study, analyze the additional V&V effort necessary for reuse of a legacy simulation for a new use that may differ from past uses.

11) Course assessment plan End of module examination

12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)

1. Technical details and advantages/disadvantages of different reuse methods; P14.1; [1] [2]
2. Appropriate reuse methods for each category (models, data, simulations); P14.1; [1] [2]
3. Model types and typical reuse methods by model type; P14.2; [1] [2]
4. Advantages/disadvantages of reuse methods by model type; P14.2; [1] [2]
5. Level of effort advantages/disadvantages of different reuse methods; P14.3; to be determined
6. Project and software estimation methods; P14.3; [3]
7. Technical details of reuse-determine concepts; P14.4; [1] [2]
8. Detailed examples of assumptions in models, data sets, and simulations; P14.5; to be determined
9. Technical details of how assumptions affect reuse applications; P14.5; to be determined
10. Technical details of reuse technologies and how each supports reuse; P14.6; [1] [2]
11. Advantages/disadvantages of different reuse technologies; P14.6; [1] [2]
12. Lists and details of existing reuse repositories; P14.7; to be determined
13. Technical details of how reuse measures encourage reuse; P14.8; to be determined
14. Technical details of levels of conceptual interoperability; P14.9; to be determined
15. Reusability implications of each level of conceptual interoperability; P14.9; to be determined
16. Advanced case studies of both successful and unsuccessful reuse in test and acquisition M&S applications; P14.10; to be determined
17. Advanced examples of cost versus benefit in reuse of legacy simulations; P14.11; to be determined
18. Advanced examples of verification and validation effort when reusing legacy simulations; P14.12; to be determined

1) Module name P14-A Reuse of models, data, and simulations (Application)

2) Coordinator

Dr. Mikel D. Petty, UAH CMSA, 256-824-4368, pettym@uah.edu

3) Module description This module comprises topics to provide training to a “Application” level of competence for program managers, systems engineers, and test and evaluation workforce members for ESR P14: Manage and reuse existing models,

data, and simulations appropriately and assure that new products developed are designed and prepared for reuse.

4) ESRs that the module supports and the corresponding level of competence  
P14 Application

5) Prerequisites assumed and the corresponding level of competence Module P14-U

6) Module maturity: Portions of the material have been taught by the module coordinator in both Old Dominion University's MSIM 601 course and in Certified Modeling and Simulation Professional examination preparation courses.

7) Number of hours estimated to deliver/teach module 16

8) Proposed delivery modalities Face-to-face lecture, synchronous distance learning (live audio/video connection), asynchronous distance learning (web or CD)

9) Proposed references and texts (topics refer to these by number)

[1] P. K. Davis and R. H. Anderson, *Improving the Composability of Department of Defense Models and Simulations*, RAND National Defense Research Institute, Santa Monica CA, 2003.

[2] E. W. Weisel, M. D. Petty, and R. R. Mielke, "A Survey of Engineering Approaches to Composability", *Proceedings of the Spring 2004 Simulation Interoperability Workshop*, Arlington VA, April 18-23 2004, pp. 722-731.

[3] W. Royce, "The COCOMO Cost Estimation Model", in W. Royce, *Software Project Management*, Addison-Wesley, Reading MA, 1998, pp. 265-281.

10) Module learning objectives Correspond to sub-ESRs for ESR P14

- a) P14.1 Define the different methods by which a model or simulation can be reused.
- b) P14.2 Given a model and a proposed reuse application for it, identify suitable methods to implement the reuse.
- c) P14.3 Determine the level of effort required to reuse a model, data set, or simulation in various applications under different reuse methods. Calculate the incremental level of effort required to make a model, data set, or simulation reusable.
- d) P14.4 Classify proposed reuse applications of a model, data set, or simulation as appropriate or inappropriate based on modeling paradigm, level of resolution, and bounds of validity.
- e) P14.5 Identify the assumptions behind a model, data set, or simulation, and determine how those assumptions constrain appropriate reuse applications.
- f) P14.6 List current simulation interoperability protocol standards, interoperability frameworks and middleware libraries, and composability approaches that support reuse, and describe the advantages and disadvantages of each.
- g) P14.7 List existing resources available for reuse, including model repositories, implemented federations, standalone simulations, standard object models, and accredited data sets, and describe the procedures for searching for resources within repositories of them.

- h) P14.8 Identify measures in new simulation development that will encourage reuse or make reuse more cost effective.
- i) P14.9 Identify the levels of conceptual interoperability possible between interoperable simulations, and describe the extent of functionality and reusability associated with each level.
- j) P14.10 Describe case studies of successful reuse applications of commonly used models, data sets, and simulations, and the characteristics of those applications that made the reuse successful.
- k) P14.11 Given a case study, analyze cost vs benefit for reuse of a legacy simulation.
- l) P14.12 Given a case study, analyze the additional V&V effort necessary for reuse of a legacy simulation for a new use that may differ from past uses.

11) Course assessment plan End of module examination

12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)

1. Determining which reuse method, if any, is being used in a given M&S application; P14.1; [1] [2]
2. Applying each of the reuse methods to models, data, and simulations as appropriate; P14.2; [1] [2]
3. Estimating level of effort to reuse an existing model, data set of simulation; P14.3; [3]
4. Estimating level of effort to prepare a new model, data set, or simulation for later reuse; P14.3; [3]
5. Estimating reuse level of effort in unusual test and acquisition M&S applications or novel reuse methods; P14.3; to be determined
6. Determining if a proposed reuse application of a model, data set, or simulation is appropriate; P14.4; [1] [2]
7. Approaches for determining if a proposed reuse application of a model, data set, or simulation is appropriate in unusual test and acquisition M&S applications or novel reuse method; P14.4; to be determined
8. Determining if a reuse application of model, data set, or simulation is appropriate based on assumptions; P14.5; to be determined
9. Applying different reuse technologies with a given test and evaluation M&S application; P14.6; [1] [2]
10. Procedures for examining, acquiring, customizing, and reusing existing resources; P14.7; to be determined
11. Given a reuse measure, applying it when developing a new model, data set, or simulation; P14.8; [1] [2]
12. Determining the level of technical interoperability present in a federation of interoperable simulation and the resulting reusability of that federation; P14.9; to be determined
13. Adapting methods and lessons regarding reuse from a case study to a new test and acquisition M&S application; P14.10; to be determined
14. Analyzing a test and acquisition M&S application for lessons learned regarding reuse; P14.10; to be determined

15. Performing cost versus benefit analysis in a legacy simulation reuse case study; P14.11; to be determined
  16. Performing verification and validation effort analysis when reusing a legacy simulation; P14.12; to be determined
- 

- 1) Module name P14-M Reuse of models, data, and simulations (Mastery)
- 2) Coordinator  
Dr. Mikel D. Petty, 256-824-4368, pettym@uah.edu
- 3) Module description This module comprises topics to provide training to a “Mastery” level of competence for program managers, systems engineers, and test and evaluation workforce members for ESR P14: Manage and reuse existing models, data, and simulations appropriately and assure that new products developed are designed and prepared for reuse.
- 4) ESRs that the module supports and the corresponding level of competence  
P14 Mastery
- 5) Prerequisites assumed and the corresponding level of competence Module P14-A
- 6) Module maturity: Portions of the material have been taught by the module coordinator in both Old Dominion University’s MSIM 601 course and in Certified Modeling and Simulation Professional examination preparation courses.
- 7) Number of hours estimated to deliver/teach module 7
- 8) Proposed delivery modalities Face-to-face lecture, synchronous distance learning (live audio/video connection), asynchronous distance learning (web or CD)
- 9) Proposed references and texts (topics refer to these by number)
  - [1] P. K. Davis and R. H. Anderson, *Improving the Composability of Department of Defense Models and Simulations*, RAND National Defense Research Institute, Santa Monica CA, 2003.
  - [2] E. W. Weisel, M. D. Petty, and R. R. Mielke, “A Survey of Engineering Approaches to Composability”, *Proceedings of the Spring 2004 Simulation Interoperability Workshop*, Arlington VA, April 18-23 2004, pp. 722-731.
  - [3] W. Royce, “The COCOMO Cost Estimation Model”, in W. Royce, *Software Project Management*, Addison-Wesley, Reading MA, 1998, pp. 265-281.
- 10) Module learning objectives Correspond to sub-ESRs for ESR P14
  - a) P14.1 Define the different methods by which a model or simulation can be reused.
  - b) P14.2 Given a model and a proposed reuse application for it, identify suitable methods to implement the reuse.

- c) P14.3 Determine the level of effort required to reuse a model, data set, or simulation in various applications under different reuse methods. Calculate the incremental level of effort required to make a model, data set, or simulation reusable.
- d) P14.4 Classify proposed reuse applications of a model, data set, or simulation as appropriate or inappropriate based on modeling paradigm, level of resolution, and bounds of validity.
- e) P14.5 Identify the assumptions behind a model, data set, or simulation, and determine how those assumptions constrain appropriate reuse applications.
- f) P14.6 List current simulation interoperability protocol standards, interoperability frameworks and middleware libraries, and composability approaches that support reuse, and describe the advantages and disadvantages of each.
- g) P14.7 List existing resources available for reuse, including model repositories, implemented federations, standalone simulations, standard object models, and accredited data sets, and describe the procedures for searching for resources within repositories of them.
- h) P14.8 Identify measures in new simulation development that will encourage reuse or make reuse more cost effective.
- i) P14.9 Identify the levels of conceptual interoperability possible between interoperable simulations, and describe the extent of functionality and reusability associated with each level.
- j) P14.10 Describe case studies of successful reuse applications of commonly used models, data sets, and simulations, and the characteristics of those applications that made the reuse successful.
- k) P14.11 Given a case study, analyze cost vs benefit for reuse of a legacy simulation.
- l) P14.12 Given a case study, analyze the additional V&V effort necessary for reuse of a legacy simulation for a new use that may differ from past uses.

11) Course assessment plan End of module examination

12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)

1. Selecting among reuse methods for an existing model based on technical considerations; P14.2; [1] [2]
2. Selecting among reuse methods for an existing model based on level of effort considerations; P14.3; [1] [2] [3]
3. Selecting among methods to prepare a new model, data set, or simulation for later reuse based on level of effort considerations; P14.3; [1] [2] [3]
4. Selecting among reuse applications for a given model, data set, or simulation; P14.4; [1] [2]
5. Approaches for analyzing and changing assumptions during model, data set, or simulation development to affect future reusability; P14.5; to be determined
6. Select among reuse measures for a new model, data set, or simulation; P14.8; to be determined
7. Selecting a case study relevant to reuse in a planned test and acquisition M&S application and extracting pertinent lessons learned; P14.10; to be determined



**P15) Manage the data strategy for an M&S effort including estimating the resources necessary to obtain sufficient data to populate the model.**

- 1) Module name: Data Strategy
- 2) Module coordinator: Marsha Taliaferro-Gillis, Ph.D.  
6596 Main Street  
Gloucester, VA 23061  
(804)694-3173 (Office)  
(804)824-4663 (Cell)  
mtgillis@werneranderson.com
- 3) Module description: Manage the data strategy for an M&S effort including estimating the resources necessary to obtain sufficient data to populate the model.
- 4) ESRs that the module supports: P15
- 5) Prerequisites assumed, and corresponding level of mastery:
- 6) Module maturity: none
- 7) Number of hours estimated to teach: 20
- 8) Proposed Delivery modality: face-to-face, on-line, VTC, resident, customer's site
- 9) Proposed references and texts

Chung, Christopher A.. 2004. *Simulation Modeling Handbook: A Practical Approach*. CRC Press LLC. Boca Raton, Florida.

Ören, Tuncer I., 2001. *Impact of Data on Simulation: From Early Practices to Federated and Agent-Directed Simulation*. Heemik et al, eds. *Proc. Of EUROISM 2001*. Delft, The Netherlands. <http://www.wite.uottawa.ca/~oren/pubs-2001-04-Delft-Data.pdf>.

Reingruber, Michael C., Gregory, William W. 1994. *The Data Modeling Handbook: A Best Practice Approach to Building Quality Data Models*, John Wiley and Sons, Inc, Canada.

Sadowski, Deborah A., Brabau, Mark R., Tips for Successful Practice of Simulation. 1999. Farrington, P. A., Nembhard, H. B., Sturrock D. T., Evans G. W., eds. Winter Simulation Conference. December 1999 Phoenix AZ USA.  
<http://www.informs-sim.org/wsc99/008.PDF>

Simsion, Graeme. 2007. *Data Modeling Theory and Practice*. Technics Publications LLC, Bradley Beach NJ.

Tolk, Adreas. 2003. Common Data Administration, Data Management, and Data Alignment as a Necessary Requirement for Coupling C4ISR Systems and M&S Systems. *INFORMATION & SECURITY: An International Journal*. Vol. 12, No. 2. 164-174 [http://cms.isn.ch/public/docs/doc\\_6954\\_259\\_en.pdf](http://cms.isn.ch/public/docs/doc_6954_259_en.pdf).

Vakali, Athena. 2007. *Web Management Data Practices: Emerging Techniques and Technologies*. Idea Group Inc, Hershey PA.

Zeigler, Bernard P., Hammonds, (Phillip E.. 2007. Modeling & Simulation-Based Data Engineering: Introducing Pragmatics into Ontologies for Net-Centric Information Exchange, Elsevier Inc., London, UK)

10) Module learning objectives:

- P15.1 Understand the role of data in M&S application and development
- P15.2 Identify common data formats for M&S applications
- P15.3 Understand fundamentals of good data management practices
- P15.4 Identify common sources of data for M&S and data repositories
- P15.5 Given a case study, identify the minimum data requirements for the decision context
- P15.6 Given a case study and a sample V&V report, evaluate whether the data validation is sufficient for the specific use
- P15.7 Given a case study and a sample V&V report, evaluate the impact and cost of low quality data on simulation output
- P15.8 Given a case study and V&V report, assess the impact and cost of data unavailability

11) Course assessment plan: projects, and exams

12) Topic list by hour of instruction and reference.

*Competency Level: General Awareness*

- i) Hour 1: Understanding the role of data in M&S application and development.
  - role of data in M&S application
  - role of data in M&S development
  - Chung, Christopher A.. 2004. *Simulation Modeling Handbook: A Practical Approach*, CRC Press LLC, Boca Raton, Florida

*Competency Level: Understanding*

- ii) Hour 2: Understanding the role of data in M&S application and development.
  - role of data in M&S application
  - role of data in M&S development

- Zeigler, Bernard P., Phillip E. Hammonds, 2007. *Modeling & Simulation-Based Data Engineering: Introducing Pragmatics into Ontologies for Net-Centric Information Exchange*, Elsevier Inc., London, UK

*Competency Level: Understanding*

- iii) Hour 3: Understanding the role of data in M&S application and development.

- role of data in M&S application
- role of data in M&S development
- Zeigler, Bernard P., Phillip E. Hammonds, 2007. *Modeling & Simulation-Based Data Engineering*:

*Competency Level: General Awareness*

- iv) Hour 4: Identify common data formats for M&S applications

- common data formats
- M&S applications
- Tolk, Adreas. 2003. Common Data Administration, Data Management, and Data Alignment as a Necessary Requirement for Coupling C4ISR Systems and M&S Systems. *INFORMATION & SECURITY: An International Journal*. Vol. 12, No. 2. 164-174  
[http://cms.isn.ch/public/docs/doc\\_6954\\_259\\_en.pdf](http://cms.isn.ch/public/docs/doc_6954_259_en.pdf) )

*Competency Level: General Awareness*

- v) Hour 5: Identify common data formats for M&S applications

- common data formats
- M&S applications
- Tolk, Adreas. 2003. Common Data Administration, Data Management, and Data Alignment as a Necessary Requirement for Coupling C4ISR Systems and M&S Systems. *INFORMATION & SECURITY: An International Journal*. Vol. 12, No. 2. 164-174  
[http://cms.isn.ch/public/docs/doc\\_6954\\_259\\_en.pdf](http://cms.isn.ch/public/docs/doc_6954_259_en.pdf) )

*Competency Level: General Awareness*

- vi) Hour 6: Understand fundamentals of good data management practices

- good Data management practices
- Simsion, Graeme. 2007. *Data Modeling Theory and Practice*. Technics Publications LLC, Bradley Beach NJ.

*Competency Level: Understanding*

- vii) Hour 7: Understand fundamentals of good data management practices

- good data management practices

- Vakali, Athena. 2007. *Web Management Data Practices: Emerging Techniques and Technologies*, Idea Group Inc, Hershey PA.

*Competency Level: Understanding*

- viii) Hour 8: Understand fundamentals of good data management practices
  - good data management practices
- Reingruber, Michael C., William W. Gregory, 1994. *The Data Modeling Handbook: A Best Practice Approach to Building Quality Data Models*, John Wiley and Sons, Inc, Canada.

*Competency Level: Understanding*

- ix) Hour 9: Understand fundamentals of good data management practices
  - good data management practices
- Reingruber, Michael C., William W. Gregory, 1994. *The Data Modeling Handbook: A Best Practice Approach to Building Quality Data Models*, John Wiley and Sons, Inc, Canada.

*Competency Level: General Awareness*

- x) Hour 10: Identify common sources of data for M&S and data repositories
  - sources of data for M&S
  - sources of data for data repositories
- Reingruber, Michael C., William W. Gregory, 1994. *The Data Modeling Handbook: A Best Practice Approach to Building Quality Data Models*, John Wiley and Sons, Inc, Canada.

*Competency Level: Understanding*

- xi) Hour 11: Given a case study, identify the minimum data requirements for the decision context
  - case study
  - minimum data requirements
  - decision context
- Reingruber, Michael C., William W. Gregory, 1994. *The Data Modeling Handbook: A Best Practice Approach to Building Quality Data Models*, John Wiley and Sons, Inc, Canada.

*Competency Level: Mastery*

- xii) Hour 12: Given a case study, identify the minimum data requirements for the decision context
  - case study
  - minimum data requirements

- decision context
- Reingruber, Michael C., William W. Gregory, 1994. *The Data Modeling Handbook: A Best Practice Approach to Building Quality Data Models*, John Wiley and Sons, Inc, Canada.

*Competency Level: Mastery*

- xiii) Hour 13: Given a case study, identify the minimum data requirements for the decision context
- case study
  - minimum data requirements
  - decision context
  - Reingruber, Michael C., William W. Gregory, 1994. *The Data Modeling Handbook: A Best Practice Approach to Building Quality Data Models*, John Wiley and Sons, Inc, Canada.

*Competency Level: Understanding*

- xiv) Hour 14: Given a case study and a sample V&V report, evaluate whether the data validation is sufficient for the specific use
- case study
  - V&V report
  - data validation
  - specific use
  - Sadowski, Deborah A., Mark R. Brabau. Tips for Successful Practice of Simulation. 1999. Farrington, P. A., Nembhard, H. B., Sturrock D. T., Evans G. W., eds. *Winter Simulation Conference*. December 1999 Phoenix AZ USA.  
<http://www.informs-sim.org/wsc99/008.PDF>

*Competency Level: Mastery*

- xv) Hour 15: Given a case study and a sample V&V report, evaluate whether the data validation is sufficient for the specific use
- case study
  - V&V report
  - data validation
  - specific use
  - Sadowski, Deborah A., Mark R. Brabau. Tips for Successful Practice of Simulation. 1999. Farrington, P. A., Nembhard, H. B., Sturrock D. T., Evans G. W., eds. *Winter Simulation Conference*. December 1999 Phoenix AZ USA.  
<http://www.informs-sim.org/wsc99/008.PDF>

*Competency Level: Mastery*

- xvi) Hour 16: Given a case study and a sample V&V report, evaluate whether the data validation is sufficient for the specific use

- case study
- V&V report
- data validation
- specific use
- Sadowski, Deborah A., Mark R. Brabau. Tips for Successful Practice of Simulation. 1999. Farrington, P. A., Nembhard, H. B., Sturrock D. T., Evans G. W., eds. *Winter Simulation Conference*. December 1999 Phoenix AZ USA.  
<http://www.informs-sim.org/wsc99/008.PDF>

*Competency Level: Understanding*

- xvii) Hour 17: Given a case study and a sample V&V report, evaluate the impact and cost of low quality data on simulation output
- case study
  - V&V report
  - impact of cost
  - impact of low quality data
  - simulation output
  - Sadowski, Deborah A., Mark R. Brabau. Tips for Successful Practice of Simulation. 1999. Farrington, P. A., Nembhard, H. B., Sturrock D. T., Evans G. W., eds. *Winter Simulation Conference*. December 1999 Phoenix AZ USA.  
<http://www.informs-sim.org/wsc99/008.PDF>

*Competency Level: Mastery*

- xviii) Hour 18: Given a case study and a sample V&V report, evaluate the impact and cost of low quality data on simulation output
- case study
  - V&V report
  - impact of cost
  - impact of low quality data
  - simulation output
  - Ören, Tuncer I., 2001. Impact of Data on Simulation: From Early Practices to Federated and Agent-Directed Simulation. Heemik et al, eds. *Proc. Of EUROISM 2001*. Delft, The Netherlands.  
<http://www.wite.uottawa.ca/~oren/pubs-2001-04-Delft-Data.pdf>

*Competency Level: Understanding*

- xix) Hour 19: Given a case study and V&V report, assess the impact and cost of data unavailability
- case study
  - V&V report
  - cost of data unavailability
  - impact of data unavailability

- Ören, Tuncer I., 2001. Impact of Data on Simulation: From Early Practices to Federated and Agent-Directed Simulation. Heemik et al, eds. *Proc. Of EUROISM 2001*. Delft, The Netherlands.  
<http://www.wite.uottawa.ca/~oren/pubs-2001-04-Delft-Data.pdf>

*Competency Level: Mastery*

xx) Hour 20: Given a case study and V&V report, assess the impact and cost of data unavailability

- case study
  - V&V report
  - cost of data unavailability
  - impact of data unavailability
- Ören, Tuncer I., 2001. Impact of Data on Simulation: From Early Practices to Federated and Agent-Directed Simulation. Heemik et al, eds. *Proc. Of EUROISM 2001*. Delft, The Netherlands.  
<http://www.wite.uottawa.ca/~oren/pubs-2001-04-Delft-Data.pdf>

1) Module name P15-G Data strategy (General awareness)

2) Coordinator

Dr. Mikel D. Petty, UAH CMSA, 256-824-4368, pettym@uah.edu

3) Module description This module comprises topics to provide training to a “General awareness” level of competence for program managers, systems engineers, and test and evaluation workforce members for ESR P15: Manage the data strategy for an M&S effort including estimating the resources necessary to obtain sufficient data to populate the model.

4) ESRs that the module supports and the corresponding level of competence  
P15 General awareness

5) Prerequisites assumed and the corresponding level of competence Basic familiarity with M&S concepts, equivalent to MSIAC M&S Staff Officers Course

6) Module maturity: Portions of the material have been taught by the module coordinator in both Old Dominion University’s MSIM 601 course and in Certified Modeling and Simulation Professional examination preparation courses.

7) Number of hours estimated to deliver/teach module 11

8) Proposed delivery modalities Face-to-face lecture, synchronous distance learning (live audio/video connection), asynchronous distance learning (web or CD)

9) Proposed references and texts (topics refer to these by number)

[1] S. Adelman, L. Moss, and M. Abai, *Data Strategy*, Addison-Wesley, 2005.

[2] B. P. Zeigler and P. E. Hammonds, *Modeling and Simulation-Based Data Engineering: Introducing Pragmatics into Ontologies for Net-Centric Information Exchange*, Academic Press, 2007.

10) Module learning objectives Correspond to sub-ESRs for ESR P15

- a) P15.1 List the categories of data sets required (such as terrain databases, Ph/Pk tables, and sensor performance parameters) for typical model and simulation types.
- b) P15.2 List the data requirements for typical test and acquisition M&S applications in terms of data sets, data volume, data availability, data accuracy, data classification, data storage media, and data archival.
- c) P15.3 Identify existing data resources available for reuse, including both unauthenticated (for simulation testing) and authenticated (for actual test use) data, and describe the procedures for searching for resources within repositories of them.
- d) P15.4 Define commonly used formats for documenting data (i.e., meta-data) and describe how to use each form to assess a data set's utility for a specific application.
- e) P15.5 For each type of data used by models and simulations, define commonly used formats for structuring and encoding the data (e.g., XML for entity performance parameters or CTDB for terrain) and describe how the format supports correct and appropriate use and reuse of data sets so structured.
- f) P15.6 Define concepts of data models (e.g., HLA object models), identify commonly used data models (e.g., HLA RPR FOM), and explain how data models relate to data sets.
- g) P15.7 Specify proper security procedures for safeguarding classified data sets, both input and output, during and between simulation executions.
- h) P15.8 Prepare for distribution of output data sets produced by simulation executions, including documenting data format, assumptions, accuracy, and applicability.
- i) P15.9 Describe approaches, identify tools, and estimate resources required for converting data sets from one format to another (e.g., converting terrain data from DTED to CTDB) if needed for a particular M&S application.
- j) P15.10 Estimate the effort required to acquire and create the data needed for a test or acquisition M&S application, based on data required for the simulation, existing data resources available, and data creation experiences.
- k) P15.11 Describe case studies of successful data acquisition and creation for data-intensive applications of commonly used models, data sets, and simulations, and the characteristics of those applications that made the reuse successful.

11) Course assessment plan End of module examination

12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)



1. Basic concepts, definitions, and examples of data set categories (e.g., terrain databases, Ph/Pk tables, and sensor performance parameters) required for typical model and simulation types; P15.1; to be determined
2. Basic concepts, definitions, and examples of data requirements for typical test and acquisition M&S applications; P15.2; to be determined
3. Basic concepts, definitions, and examples of each type of existing data resource; P15.3; to be determined
4. Basic concepts, definitions, and examples of data documentation formats; P15.4; [1] [2]
5. Basic concepts, definitions, and examples of data encoding formats; P15.5; [1] [2]
6. Basic concepts, definitions, and examples of data models; P15.6; [1] [2]
7. Basic concepts, definitions, and examples of data security procedures; P15.7; [1] [2]
8. Basic concepts, definitions, and examples of simulation data distribution; P15.8; [2]
9. Basic concepts, definitions, and examples of data conversion; P15.9; [1] [2]
10. Basic concepts, definitions, and examples of data acquisition and creation effort; P15.10; to be determined
11. Simple case studies of successful data acquisition and creation in test and acquisition M&S applications; P15.11; to be determined

1) Module name P15-U Data strategy (Understanding)

2) Coordinator

Dr. Mikel D. Petty, UAH CMSA, 256-824-4368, pettym@uah.edu

3) Module description This module comprises topics to provide training to a “Understanding” level of competence for program managers, systems engineers, and test and evaluation workforce members for ESR P15: Manage the data strategy for an M&S effort including estimating the resources necessary to obtain sufficient data to populate the model.

4) ESRs that the module supports and the corresponding level of competence  
P15 Understanding

5) Prerequisites assumed and the corresponding level of competence Module P15-G.

6) Module maturity Portions of the material have been taught by the module coordinator in both Old Dominion University’s MSIM 601 course and in Certified Modeling and Simulation Professional examination preparation courses

7) Number of hours estimated to deliver/teach module 14

8) Proposed delivery modalities Face-to-face lecture, synchronous distance learning (live audio/video connection), asynchronous distance learning (web or CD)

9) Proposed references and texts topics refer to these by number

[1] S. Adelman, L. Moss, and M. Abai, *Data Strategy*, Addison-Wesley, 2005.

[2] B. P. Zeigler and P. E. Hammonds, *Modeling and Simulation-Based Data Engineering: Introducing Pragmatics into Ontologies for Net-Centric Information Exchange*, Academic Press, 2007.

- 10) Module learning objectives Correspond to sub-ESRs for ESR P15
  - a) P15.1 List the categories of data sets required (such as terrain databases, Ph/Pk tables, and sensor performance parameters) for typical model and simulation types.
  - b) P15.2 List the data requirements for typical test and acquisition M&S applications in terms of data sets, data volume, data availability, data accuracy, data classification, data storage media, and data archival.
  - c) P15.3 Identify existing data resources available for reuse, including both unauthenticated (for simulation testing) and authenticated (for actual test use) data, and describe the procedures for searching for resources within repositories of them.
  - d) P15.4 Define commonly used formats for documenting data (i.e., meta-data) and describe how to use each form to assess a data set's utility for a specific application.
  - e) P15.5 For each type of data used by models and simulations, define commonly used formats for structuring and encoding the data (e.g., XML for entity performance parameters or CTDB for terrain) and describe how the format supports correct and appropriate use and reuse of data sets so structured.
  - f) P15.6 Define concepts of data models (e.g., HLA object models), identify commonly used data models (e.g., HLA RPR FOM), and explain how data models relate to data sets.
  - g) P15.7 Specify proper security procedures for safeguarding classified data sets, both input and output, during and between simulation executions.
  - h) P15.8 Prepare for distribution of output data sets produced by simulation executions, including documenting data format, assumptions, accuracy, and applicability.
  - i) P15.9 Describe approaches, identify tools, and estimate resources required for converting data sets from one format to another (e.g., converting terrain data from DTED to CTDB) if needed for a particular M&S application.
  - j) P15.10 Estimate the effort required to acquire and create the data needed for a test or acquisition M&S application, based on data required for the simulation, existing data resources available, and data creation experiences.
  - k) P15.11 Describe case studies of successful data acquisition and creation for data-intensive applications of commonly used models, data sets, and simulations, and the characteristics of those applications that made the reuse successful.
- 11) Course assessment plan End of module examination.
- 12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)
  1. Technical details of simulation data sets, including representation, resolution, fidelity, and size, for typical model and simulation types; P15.1; [2]
  2. Technical details and normal value ranges of data requirement parameters (e.g., data sets, data volume, data availability, data accuracy, data classification, data storage media, data archival; P15.2; .[2]
  3. Lists and details of existing data repositories; P15.3; to be determined

4. Technical details and advanced examples of data documentation formats; P15.4; [1] [2]
  5. Technical details and advanced examples of data encoding formats; P15.5; [1] [2]
  6. Technical details and advanced examples of data models; P15.6; [1] [2]
  7. Relationship of data models to data sets; P15.6; [1] [2]
  8. Data security requirements and procedures; P15.7; to be determined
  9. Advanced examples of data security in test and acquisition M&S applications; P15.7; to be determined
  10. Advanced examples of data distribution in test and acquisition M&S applications; P15.8; to be determined
  11. Advanced examples of data conversion for test and acquisition M&S applications; P15.9; to be determined
  12. Available data conversion tools and utilities; P15.9; to be determined
  13. Advanced examples of data acquisition and creation effort in test and acquisition M&S applications; P15.10; to be determined
  14. Advanced case studies of both successful and unsuccessful data acquisition and creation in test and acquisition M&S applications; P15.11; to be determined
- 

1) Module name P15-A Data strategy (Application)

2) Coordinator

Dr. Mikel D. Petty, UAH CMSA, 256-824-4368, pettym@uah.edu

3) Module description This module comprises topics to provide training to a “Application” level of competence for program managers, systems engineers, and test and evaluation workforce members for ESR P15: Manage the data strategy for an M&S effort including estimating the resources necessary to obtain sufficient data to populate the model.

4) ESRs that the module supports and the corresponding level of competence  
P15 Application

5) Prerequisites assumed and the corresponding level of competence Module P15-U

6) Module maturity: Portions of the material have been taught by the module coordinator in both Old Dominion University’s MSIM 601 course and in Certified Modeling and Simulation Professional examination preparation courses.

7) Number of hours estimated to deliver/teach module 13

8) Proposed delivery modalities Face-to-face lecture, synchronous distance learning (live audio/video connection), asynchronous distance learning (web or CD)

9) Proposed references and texts (topics refer to these by number)

- [1] S. Adelman, L. Moss, and M. Abai, *Data Strategy*, Addison-Wesley, 2005.
- [2] B. P. Zeigler and P. E. Hammonds, *Modeling and Simulation-Based Data Engineering: Introducing Pragmatics into Ontologies for Net-Centric Information Exchange*, Academic Press, 2007.

- 10) Module learning objectives Correspond to sub-ESRs for ESR P15
  - a) P15.1 List the categories of data sets required (such as terrain databases, Ph/Pk tables, and sensor performance parameters) for typical model and simulation types.
  - b) P15.2 List the data requirements for typical test and acquisition M&S applications in terms of data sets, data volume, data availability, data accuracy, data classification, data storage media, and data archival.
  - c) P15.3 Identify existing data resources available for reuse, including both unauthenticated (for simulation testing) and authenticated (for actual test use) data, and describe the procedures for searching for resources within repositories of them.
  - d) P15.4 Define commonly used formats for documenting data (i.e., meta-data) and describe how to use each form to assess a data set's utility for a specific application.
  - e) P15.5 For each type of data used by models and simulations, define commonly used formats for structuring and encoding the data (e.g., XML for entity performance parameters or CTDB for terrain) and describe how the format supports correct and appropriate use and reuse of data sets so structured.
  - f) P15.6 Define concepts of data models (e.g., HLA object models), identify commonly used data models (e.g., HLA RPR FOM), and explain how data models relate to data sets.
  - g) P15.7 Specify proper security procedures for safeguarding classified data sets, both input and output, during and between simulation executions.
  - h) P15.8 Prepare for distribution of output data sets produced by simulation executions, including documenting data format, assumptions, accuracy, and applicability.
  - i) P15.9 Describe approaches, identify tools, and estimate resources required for converting data sets from one format to another (e.g., converting terrain data from DTED to CTDB) if needed for a particular M&S application.
  - j) P15.10 Estimate the effort required to acquire and create the data needed for a test or acquisition M&S application, based on data required for the simulation, existing data resources available, and data creation experiences.
  - k) P15.11 Describe case studies of successful data acquisition and creation for data-intensive applications of commonly used models, data sets, and simulations, and the characteristics of those applications that made the reuse successful.

11) Course assessment plan End of module examination

12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)

- 1. Determining data set categories for typical model and simulation types; P15.1; [2]
- 2. Determining data requirements for typical test and acquisition M&S applications; P15.2; [2]
- 3. Procedures for examining, acquiring, customizing, and reusing existing data resources; P15.3; to be determined

4. Using data documentation in each format to evaluate data utility; P15.4; [1] [2]
  5. Using data encoding formats to encode or decode simulation data; P15.5; [1] [2]
  6. Using data models to structure and organize data within a test and acquisition M&S application; P15.6; [1] [2]
  7. Instituting and executing data security in test and acquisition M&S applications; P15.7; to be determined
  8. Performing data distribution in test and acquisition M&S applications; P15.8; to be determined
  9. Performing data conversion for test and acquisition M&S applications; P15.9; to be determined
  10. Effects of data conversion on data resolution and accuracy; P15.9; to be determined
  11. Estimating effort required for data acquisition and creation in test and acquisition M&S applications; P15.10; to be determined
  12. Adapting methods and lessons regarding data acquisition and creation from a case study to a new test and acquisition M&S application; P15.11; to be determined
  13. Analyzing a test and acquisition M&S application for lessons learned regarding data acquisition and creation; P15.11; to be determined
- 

1) Module name P15-M Data strategy (Mastery)

2) Coordinator

Dr. Mikel D. Petty, UAH CMSA, 256-824-4368, pettym@uah.edu

3) Module description This module comprises topics to provide training to a “Mastery” level of competence for program managers, systems engineers, and test and evaluation workforce members for ESR P15: Manage the data strategy for an M&S effort including estimating the resources necessary to obtain sufficient data to populate the model.

4) ESRs that the module supports and the corresponding level of competence  
P15 Mastery

5) Prerequisites assumed and the corresponding level of competence Module P15-A

6) Module maturity Portions of the material have been taught by the module coordinator in both Old Dominion University’s MSIM 601 course and in Certified Modeling and Simulation Professional examination preparation courses.

7) Number of hours estimated to deliver/teach module 2

8) Proposed delivery modalities Face-to-face lecture, synchronous distance learning (live audio/video connection), asynchronous distance learning (web or CD)

9) Proposed references and texts (topics refer to these by number)

[1] S. Adelman, L. Moss, and M. Abai, *Data Strategy*, Addison-Wesley, 2005.

[2] B. P. Zeigler and P. E. Hammonds, *Modeling and Simulation-Based Data Engineering: Introducing Pragmatics into Ontologies for Net-Centric Information Exchange*, Academic Press, 2007.

- 10) Module learning objectives Correspond to sub-ESRs for ESR P15
  - a) P15.1 List the categories of data sets required (such as terrain databases, Ph/Pk tables, and sensor performance parameters) for typical model and simulation types.
  - b) P15.2 List the data requirements for typical test and acquisition M&S applications in terms of data sets, data volume, data availability, data accuracy, data classification, data storage media, and data archival.
  - c) P15.3 Identify existing data resources available for reuse, including both unauthenticated (for simulation testing) and authenticated (for actual test use) data, and describe the procedures for searching for resources within repositories of them.
  - d) P15.4 Define commonly used formats for documenting data (i.e., meta-data) and describe how to use each form to assess a data set's utility for a specific application.
  - e) P15.5 For each type of data used by models and simulations, define commonly used formats for structuring and encoding the data (e.g., XML for entity performance parameters or CTDB for terrain) and describe how the format supports correct and appropriate use and reuse of data sets so structured.
  - f) P15.6 Define concepts of data models (e.g., HLA object models), identify commonly used data models (e.g., HLA RPR FOM), and explain how data models relate to data sets.
  - g) P15.7 Specify proper security procedures for safeguarding classified data sets, both input and output, during and between simulation executions.
  - h) P15.8 Prepare for distribution of output data sets produced by simulation executions, including documenting data format, assumptions, accuracy, and applicability.
  - i) P15.9 Describe approaches, identify tools, and estimate resources required for converting data sets from one format to another (e.g., converting terrain data from DTED to CTDB) if needed for a particular M&S application.
  - j) P15.10 Estimate the effort required to acquire and create the data needed for a test or acquisition M&S application, based on data required for the simulation, existing data resources available, and data creation experiences.
  - k) P15.11 Describe case studies of successful data acquisition and creation for data-intensive applications of commonly used models, data sets, and simulations, and the characteristics of those applications that made the reuse successful.
- 11) Course assessment plan End of module examination
- 12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)
  1. Selecting among data acquisition and creation alternatives; P15.10; [1] [2]
  2. Selecting a case study relevant to data acquisition and creation in a planned test and acquisition M&S application and extracting pertinent lessons learned; P15.11; to be determined

**A1) Describe the types, role and value of formal Modeling and Simulations, and their various characterizations for application to systems management, particularly with regard to design, testing, training, production, cost estimation, manning, and logistical simulations.**

- 1) Title: Roles and Value of M&S Applications
- 2) Module coordinator / point of contact and contact information  
Jim Campbell, GMU, [jcampbell@alionscience.com](mailto:jcampbell@alionscience.com), 703-933-3356
- 3) Module description (short description) At the completion of this module, students will be able to apply example cases of M&S tools for design, testing, training, production, cost estimation, manning, and logistical simulations as they are used across the life cycle. Taught to the Application Level; for courses at the understanding or general awareness level, time can be reduced and practical application periods deleted.
- 4) ESR supported: A1—Describe the types, role and value of formal Modeling and Simulations, and their various characterizations for application to systems management, particularly with regard to design, testing, training, production, cost estimation, manning, and logistical simulations.
- 5) Prerequisites: ACQ 101, ACQ 201, ESR P10.
- 6) Module maturity: The first four objectives are taught in the MSIAC's Modeling and Simulation Staff Officer's Course and in the Army's Simulation Operations Qualification Course, but the material is at the general awareness level.
- 7) Number of hours Twelve.
- 8) Proposed Delivery modality face-to-face, or VTC; resident, or customer's site
- 9) Proposed references and texts
  - h) DoD Directive 5000.1, Defense Acquisition System, 12 May 2003
  - i) DoD Instruction 5000.2, Operation of the Defense Acquisition System, 12 May 2003
  - j) DoD Directive 5000.59, DoD Modeling and Simulation (M&S) Management, 8 August 2007
  - k) Defense Acquisition Guidebook, Version 1.0, 17 October 2004
  - l) Department of Defense Acquisition Modeling and Simulation Master Plan, 17 April, 2006

- m) AR 5-11, Management of Army Models & Simulations, 1 February 2005
  - n) OPNAVINST 5200.34, Navy Modeling and Simulation (M&S) Management, 28 May 2002
  - o) AFDP 16-10, Modeling And Simulation (M&S) Management, 30 January 1995
  - p) Committee on Modeling and Simulation Enhancements for 21<sup>st</sup> Century Manufacturing and Defense Acquisition, National Research Council. Modeling and Simulation in Manufacturing and Defense Acquisition: Pathways to Success. Washington, D.C.: The National Academies Press, 2002.
  - q) Director for Test, Systems Engineering and Evaluation Study. Study on the Effectiveness of Modeling and Simulation in the Weapon System Acquisition Process. Washington D.C., October 1996.
- 10) Module learning objectives:
- A1.1: List the three types of models
  - A1.2: Describe the purpose and characteristics of each type of model
  - A1.3: List the three types of simulations
  - A1.4: Describe the purpose and characteristics of each type of simulation
  - A1.5: Describe how M&S is used in systems design
  - A1.6: Describe how M&S is used in systems testing
  - A1.7: Describe how M&S is used in systems training
  - A1.8: Describe how M&S is used in systems production
  - A1.9: Describe how M&S is used in systems cost estimation
  - A1.10: Describe how M&S is used in systems manpower integration
  - A1.11: Describe how M&S is used in systems logistics planning and execution
- 11) Course assessment plan: Examination and practical exercise.
- 12) Topic list by hour of instruction and reference:
- i) Hour one: Overview of M&S (course notes and syllabus) A1.1- A1.4
  - ii) Hour two: M&S in system design (course notes and syllabus) A1.5
  - iii) Hour three: M&S in system testing (course notes and syllabus) A1.6
  - iv) Hour four: Practical application (course notes and syllabus) A1.5, A1.6
  - v) Hour five: M&S in system training (course notes and syllabus) A1.7
  - vi) Hour six: M&S in system MANPRINT (course notes and syllabus) A1.10
  - vii) Hour seven: Practical application (course notes and syllabus) A1.7, A1.10
  - viii) Hour eight: M&S in system production (course notes and syllabus) A1.8
  - ix) Hour nine: M&S in system cost estimation (course notes and syllabus) A1.9
  - x) Hour ten: M&S in system sustainment (course notes and syllabus) A1.11
  - xi) Hour eleven: Practical application (course notes and syllabus) A1.9, A1.11
  - xii) Hour twelve: Examination and summary (course notes and syllabus) A1all
- 13) Additional Requirements: N/A.



**A2) Define the critical decisions in the acquisition lifecycle and how/what M&S is used to inform those decisions in order to reduce the time, resources, and risks associated with the acquisition process.**

- 1) Title: M&S Support for Acquisition Decisions
- 2) Module coordinator / point of contact and contact information  
Jim Campbell, GMU, [jcampbell@alionscience.com](mailto:jcampbell@alionscience.com), 703-933-3356
- 3) Module description (short description) At the completion of this module, students will be able to identify the six critical decisions in the Acquisition process and apply representative M&S tools to support those decisions. Taught to the Application Level; for courses at the understanding or general awareness level, time can be reduced and practical application periods deleted.
- 4) ESR supported: A2— Define the critical decisions in the acquisition lifecycle and how/what M&S is used to inform those decisions in order to reduce the time, resources, and risks associated with the acquisition process.
- 5)
- 6) Prerequisites: ACQ 101, ACQ 201.
- 7) Module maturity: This information is not specifically taught in the MSSOC or GMU CPE course, however, much of the information is provided in a slightly different framework at the understanding level.
- 8) Number of hours: Eight.
- 9) Proposed Delivery: modality face-to-face, or VTC; resident, or customer's site
- 10) Proposed references and texts:
  - a) DoD Directive 5000.1, Defense Acquisition System, 12 May 2003
  - b) DoD Instruction 5000.2, Operation of the Defense Acquisition System, 12 May 2003
  - c) DoD Directive 5000.59, DoD Modeling and Simulation (M&S) Management, 8 August 2007
  - d) Defense Acquisition Guidebook, Version 1.0, 17 October 2004
  - e) CJCSI 3170.01F, Joint Capabilities Integration and Development System, 1 May 2007

- f) CJCSM 3170.01C, Operation of the Joint Capabilities Integration and Development system, 1 May 2007

11) Module learning objectives:

- A2.1: Identify the six critical decisions in the acquisition lifecycle.
- A2.2: Describe primary and secondary types of M&S functions that support each critical decision.
- A2.3: Identify the intended use of each type of M&S supporting the six critical decisions.
- A2.4: Identify representative examples of each type of M&S supporting the six critical decisions.

12) Course assessment plan: Examination and practical exercise.

13) Topic list by hour of instruction and reference:

- i) Hour one: Introduction and overview (DoDD 5000.1, DoDI 5000.2, CJCSI 3170.01F) A2.1
- ii) Hour two: M&S in support of the Concept Decision and the Milestone A Decision (course notes and syllabus) A2.2-4
- iii) Hour three: M&S in support of the Milestone B Decision (course notes and syllabus) A2.2-4
- iv) Hour four: M&S in support of the Design Readiness Review (course notes and syllabus) A2.2-4
- v) Hour five: M&S in support of the Milestone C Decision (course notes and syllabus) A2.2-4
- vi) Hour six: M&S in support of the Full Rate Production Decision (course notes and syllabus) A2.2-4
- vii) Hour seven: Practical application (course notes and syllabus) A2 all
- viii) Hour eight: Evaluation and Summary (course notes and syllabus) A2 all

14) Additional Requirements: N/A

---

Course Name: Applying Commercial Simulation-Based Acquisition Metaphors

*Course Coordinator:*

Michael D. Proctor, Ph.D., LTC (Retired)  
Associate Professor, CMSP  
IEMS & IDS M&S  
University of Central Florida  
Engineering Building 2, Room 301-D  
Tel: 407-823-5296  
Fax: 407-823-3413

[mproctor@mail.ucf.edu](mailto:mproctor@mail.ucf.edu)  
<http://people.cecs.ucf.edu/proctor>

*Course Description:*

This course will provide an *application capability* of essential skill requirements of non-DoD concepts of Simulation-Based Acquisition (SBA) across the entire program life cycle of commercial companies, in order to gain possible new insights into reducing the time, resources, and risks associated with the DoD acquisition process.

*Modules incorporated into Course:*

This course incorporates material covered in the Awareness and Understanding courses (modules) and will reuse the Awareness level online course learning module as is if developed.

*ESR Supporting the Course*

ESR A2: Sub ESRs taught at the Application level

*Pre-requisite*

1. Rank/Seniority:  
Active Military: O-1 and above  
Government Civilian: GS-5 and above
2. Pre-Course/Training:  
CLE011 and CLE023 or equivalent

*Course Maturity*

Base on UCF course EIN6528 which was first taught as a Special Topic in 2003.

*Contact Hours / Pace of Completion*

This is a 3-day course with 24 contact hours. The course can be completed with 8hr-instruction per day.

*Proposed Delivery Modality*

Face-to-face teaching and will reuse the Awareness level online course learning module if developed.

*Proposed Reference and Text*

- Morgan, James M. and Liker, Jeffrey K., (2006) The Toyota Product Development System
- Harvard Business School Case studies course packet currently consisting of: Boeing: 9-305-101; Boeing: 9-688-040; Millennium Pharmaceuticals, Inc 9-600-038; BMW: 9-699-044; 9-699-045; Toyota: 9-602-035; Renault-Nissan: 9-303-023; IDEO: 9-600-143

Other references:

- Bonabeau, E. (2002), "Predicting the Unpredictable," Harvard Business Review, March.
- Chambers, John C., Mullick, Satinder, and Donald D. Smith. "How to Choose the Right Forecasting Technique," HBR, July – August 1971.
- Elberse, Anita. "How Markets Help Marketers," HBR, September 2005.
- Fuchs, et al. "Strategic Integration," CMR, Spring 2000
- Georgoff, David M. & Murdick, Robert G. "Manager's Guide to Forecasting," HBR, Jan-Feb 1986
- Goldhar, Joel D. & Mariann Jelinek. "Plan for Economies of Scope," HBR November-December 1983.
- Hamel, Gary & Prahalad, C.K. "Strategic Intent," HBR, July – August 2005.
- Harvard Management Update, "Should You Be Using Simulations?" June 2000.
- Kallio, et al. "Drivers and tracers of business changes," Journal of Strategic Information Systems, 8, 1999
- Malhotra, Deepak. "Negotiate or Litigate?" Negotiation, October 2004
- Porter and Millar, "How information gives you competitive advantage," HBR, July 85. (value chain article).
- Porter, "How competitive forces shape strategy," HBR, March 1979.
- Quinn, James Brian. "Technological Forecasting," HBR, March-April 1967.
- Raynor, Michael & Jil Panetta. "A Better Way to R&D?" Strategy & Innovation, March – April, 2005.
- Ring, Peter Smith, Doz, Yves L., & Olk, Paul M. "Managing Formation Processes in R&D Consortia," CMR, Vol. 47, No. 4, Summer 2005.
- Sirkin, Harold, Keenan, Perry, & Alan Jackson. "The Hard Side of Change Management," HBR, Oct 2005
- Sobek, et al. "Another Look at How Toyota Integrates Product Development," HBR, July-August 1998.
- Spear, Steven & Bowen, H. Kent, "Decoding the DNA of the Toyota Production System," HBR, Sept – Oct 1999
- Sterman, John D., "System Dynamics Modeling: Tools for Learning in a Complex World," CMR, Vol. 43, Num. 4, Summer 2001.
- Susskind, Lawrence, "Full Engagement: Learning the Most from Negotiation Simulations," Negotiation, August 2005
- Thomke, "Simulation, learning and R&D performance," Research Policy 27 (1998)
- Thomke, "Capturing the Real Value of Innovation Tools," MIT Sloan Management Review, Winter 2006

- Thomke, “Enlightened Experimentation: The New Imperative for Innovation,” HBR, Feb 2001.
- Thomke, Stefan & Hippel, Eric von, “Customers as Innovators: A New Way to Create Value,” HBR April 2002.
- Ward, et al. “The Second Toyota Paradox,” Sloan Management Review, Spring 1995.

### *Course Learning Objectives*

Students who have successfully completed this course will be able to:

1. Applies commercial acquisition strategies to multiple examples (ESR A2.1)
2. Uses M&S concepts to anticipate benefits to commercial aircraft industry (ESR A2.2)
3. Uses M&S concepts to anticipate benefits to commercial automotive industry (ESR A2.3)
4. Uses M&S concepts to anticipate benefits to commercial Pharmaceutical industry (ESR A2.4)
5. Constructs possible change management approaches associated with M&S adoption (ESR A2.5)
6. Predicts possible impacts of emerging CASE tool technologies and their contribution to corporate integration (ESR A2.6)

### *Course Assessment Plan*

Verbal Feedback during Class- to periodically check on students’ understanding of topics taught

End-of-Course Evaluation- open and closed questions to test student’s proficiency on the topics taught

Hands-on Software Training and Scenario-based Testing- short scenario-based assignment similar to case studies taught to test students’ ability in M&S software usage

Hour-by-hour Instruction:

Hour 1 and 2: ESR A2.1: Overview of commercial acquisition strategies and terminology, Syllabus

Hour 3 through 8: ESR A2.2: Introduction to M&S benefits to commercial aircraft  
Commercial case history of HOW M&S has been used to advance and sustain quality and distribute production world-wide by global commercial aircraft manufacturers from the foundation of aviation with the Wright brothers to the most current aircraft.

\*Porter, HBR, March 1979

\*Fuchs, et al CMR 2000

\*Porter and Millar, HBR, July 85.

\*Hamel & Prahalad, HBR, 2005

\*HBR Case 9-305-101;

- \*Quinn, HBR 1967;
- \*Chambers, et al., HBR 1971;
- \*Georgoff & Murdick, HBR 1986
- \*HBS Case 9-688-040

Hour 9 and 17: ESR A2.3: Introduction to M&S benefits to commercial automotive industries. Commercial case history of recent radical changes in HOW M&S has been used by a Global Automotive Company to radically alter their entire software infrastructure, re-train their work force, rapidly close and then surpass other Global Automotive Commercial Companies through the productivity and time to market gains made possible through M&S

- \*HBS Case 9-602-035;
- \*Morgan, James M. and Liker, Jeffrey K., (2006) The Toyota Product Development System \*Ward, et al, Sloan Management Review, Spring 1995;
- \*Sobek, Liker & Ward, HBR July-August 1998;
- \*Spear & Bowen, HBR, 1999
- \*Thomke, MIT, 2006
- \*Thomke, HBR, 2001
- \*HBS Case 9-699-044 & 045
- \*HBS Case 9-303-023
- \*Thomke, Research Policy 27 (1998) 55-74;
- \*Goldhar & Jelink, HBR, 1983

Hour 18 and 19: ESR A2.4: Introduction to M&S benefits to commercial Pharmaceutical industries,

- \*HBS 9-600-038
- \*Raynor & Panetta, S&I, 2005
- \*Stermann, CMR, 2001
- \*Ring et al, CMR, 2005

Hour 20 through 22: ESR A2.5: Commercial case history of change management issues and approaches as it relates to M&S adoption and proliferation. Change management due to M&S tool adoption (45 hour course would have a 3 hour Student report and presentation)

- \*Susskind, Negotiation, 2005
- \*Harvard Update, 2000
- \*Bonabeau, 2002
- \*Kallio, et al Journal, 1999
- \*Sirkin, et al, HBR, 2005
- \*Malhotra, Negotiation, 2004

Hour 23 and 24: ESR A2.6: Change emerging trends in CASE tool applications, Sectional Review, Conclusion, End-of-Course Test

- \*Contemporary articles

*Course Name:* Awareness of Commercial Simulation-Based Acquisition Metaphors

*Course Coordinator*

Michael D. Proctor, Ph.D., LTC (Retired)  
Associate Professor, CMSP  
IEMS & IDS M&S  
University of Central Florida  
Engineering Building 2, Room 301-D  
Tel: 407-823-5296  
Fax: 407-823-3413  
[mproctor@mail.ucf.edu](mailto:mproctor@mail.ucf.edu)  
<http://people.cecs.ucf.edu/proctor>

*Course Description*

This course will provide a *general awareness* of non-DoD concepts of Simulation-Based Acquisition (SBA) across the entire program life cycle of commercial companies, in order to gain possible new insights into reducing the time, resources, and risks associated with the DoD acquisition process.

*Modules incorporated into Course:*

This course is a basic entry course or a fundamental module. This course can be incorporated as a module into the Introduction, Application, and Masters level course offerings related to this same ESR.

*ESR Supporting the Course:*

ESR A2: General Awareness for each sub ESR.

*Pre-requisite*

1. Rank/Seniority:  
Active Military: O-1 or higher  
Government Civilian: GS-5 or higher
2. Pre-Course/Training:  
CLE011 and CLE023 or equivalent

*Course Maturity*

Base on UCF course EIN6528 which was first taught as a Special Topic in 2003.

*Contact Hours / Pace of Completion*

This is a non-Resident, self paced 3 hr-online course that may take between 2 and 6 hours depending of the prior experience and skills of the students. Students must pass the End-of-Course test within 30 calendar days of the start date.

*Proposed Delivery Modality*  
Online Learning course.

*Proposed Reference and Text*

- Morgan, James M. and Liker, Jeffrey K., (2006) The Toyota Product Development System
- Bonabeau, E. (2002), "Predicting the Unpredictable," Harvard Business Review, March.
- Chambers, John C., Mullick, Satinder, and Donald D. Smith. "How to Choose the Right Forecasting Technique," HBR, July – August 1971.
- Elberse, Anita. "How Markets Help Marketers," HBR, September 2005.
- Fuchs, et al. "Strategic Integration," CMR, Spring 2000
- Georgoff, David M. & Murdick, Robert G. "Manager's Guide to Forecasting," HBR, Jan-Feb 1986
- Goldhar, Joel D. & Mariann Jelinek. "Plan for Economies of Scope," HBR November-December 1983.
- Hamel, Gary & Prahalad, C.K. "Strategic Intent," HBR, July – August 2005.
- Harvard Management Update, "Should You Be Using Simulations?" June 2000.
- Kallio, et al. "Drivers and tracers of business changes," Journal of Strategic Information Systems, 8, 1999
- Malhotra, Deepak. "Negotiate or Litigate?" Negotiation, October 2004
- Porter and Millar, "How information gives you competitive advantage," HBR, July 85. (value chain article).
- Porter, "How competitive forces shape strategy," HBR, March 1979.
- Quinn, James Brian. "Technological Forecasting," HBR, March-April 1967.
- Raynor, Michael & Jil Panetta. "A Better Way to R&D?" Strategy & Innovation, March – April, 2005.
- Ring, Peter Smith, Doz, Yves L., & Olk, Paul M. "Managing Formation Processes in R&D Consortia," CMR, Vol. 47, No. 4, Summer 2005.
- Sirkin, Harold, Keenan, Perry, & Alan Jackson. "The Hard Side of Change Management," HBR, Oct 2005
- Sobek, et al. "Another Look at How Toyota Integrates Product Development," HBR, July-August 1998.
- Spear, Steven & Bowen, H. Kent, "Decoding the DNA of the Toyota Production System," HBR, Sept – Oct 1999
- Serman, John D., "System Dynamics Modeling: Tools for Learning in a Complex World," CMR, Vol. 43, Num. 4, Summer 2001.
- Susskind, Lawrence, "Full Engagement: Learning the Most from Negotiation Simulations," Negotiation, August 2005
- Thomke, "Simulation, learning and R&D performance," Research Policy 27 (1998)
- Thomke, "Capturing the Real Value of Innovation Tools," MITSloan Management Review, Winter 2006



- Thomke, “Enlightened Experimentation: The New Imperative for Innovation,” HBR, Feb 2001.
- Thomke, Stefan & Hippel, Eric von, “Customers as Innovators: A New Way to Create Value,” HBR April 2002.
- Ward, et al. “The Second Toyota Paradox,” Sloan Management Review, Spring 1995.

### *Course Learning Objectives*

Students who have successfully completed this course will be able to:

1. Identify commercial acquisition strategies (ESR A2.1)
2. Identify M&S benefits to commercial aircraft industry (ESR A2.2)
3. Identify M&S benefits to commercial automotive industry (ESR A2.3)
4. Identify M&S benefits to commercial Pharmaceutical industry (ESR A2.4)
5. Identify change management issues associated with M&S adoption (ESR A2.5)
6. Identify emerging CASE tool technologies and their contribution to corporate integration (ESR A2.6)

### *Course Assessment Plan*

Sectional Reviews- sets of multiple choice questions specific to each topic at the end of each course section

End-of-Course Test- general multiple choice questions on all topics taught

### *Hour-by-hour Instruction*

Hour 1: ESR A2.1& A2.2: Overview of commercial acquisition strategies and terminology and Introduction to M&S benefits to commercial aircraft.

Hour 2: ESR A2.3 & A2.4: Introduction to M&S benefits to automotive, and Pharmaceutical industries, Selected Highlights from all references above.

Hour 3: ESR A2.5 & A2.6: Change management and emerging trends in M&S tool applications, Sectional Review, Conclusion, End-of-Course Test

---

*Course Name:* Commercial Simulation-Based Acquisition Metaphors

### *Course Coordinator*

Michael D. Proctor, Ph.D., LTC (Retired)  
Associate Professor, CMSP  
IEMS & IDS M&S

University of Central Florida  
Engineering Building 2, Room 301-D  
Tel: 407-823-5296  
Fax: 407-823-3413  
[mproctor@mail.ucf.edu](mailto:mproctor@mail.ucf.edu)  
<http://people.cecs.ucf.edu/proctor>

*Course Description*

This course will provide an *educational mastery* (a masters level course that is part of a masters program in modeling and simulation) of essential skill requirements of non-DoD concepts of Simulation-Based Acquisition (SBA) across the entire program life cycle of commercial companies, in order to gain possible new insights into reducing the time, resources, and risks associated with the DoD acquisition process.

*Modules incorporated into Course:*

This course incorporates ESR A2 material covered in the Awareness, Understanding, and Application courses (modules) and will reuse the Awareness level online course learning module if developed.

*ESR Supporting the Course:*

ESR A2: Sub ESR taught at Educational Mastery (part of a masters program) competency level or at the maximum level specified in the matrix.

*Pre-requisite*

1. Rank/Seniority:  
Active Military: O-3 and above  
Government Civilian: GS-9 and above
2. Pre-Course/Training:  
CLE011 and CLE023 or equivalent

*Course Maturity*

Base on UCF course EIN6528 which was first taught as a Special Topic in 2003.

*Contact Hours / Pace of Completion*

This is a quarter or semester-long (12 to 15 weeks) course with 36 to 45 contact hours with 3hr-instruction per week. Alternatively the course may be accomplished in a shorter period of time covering the same number of contact hours but with a faster paced setting being 6 hours per week.

*Proposed Delivery Modality*

The course is a mixture of face-to-face teaching and will reuse the Awareness level online course learning module if that online course (module) is developed.

*Proposed Reference and Text*

- Morgan, James M. and Liker, Jeffrey K., (2006) The Toyota Product Development System
- Harvard Business School Case studies course packet currently consisting of: Boeing: 9-305-101; Boeing: 9-688-040; Millennium Pharmaceuticals, Inc 9-600-038; BMW: 9-699-044; 9-699-045; Toyota: 9-602-035; Renault-Nissan: 9-303-023; IDEO: 9-600-143

Other references:

- Bonabeau, E. (2002), "Predicting the Unpredictable," Harvard Business Review, March.
- Chambers, John C., Mullick, Satinder, and Donald D. Smith. "How to Choose the Right Forecasting Technique," HBR, July – August 1971.
- Elberse, Anita. "How Markets Help Marketers," HBR, September 2005.
- Fuchs, et al. "Strategic Integration," CMR, Spring 2000
- Georgoff, David M. & Murdick, Robert G. "Manager's Guide to Forecasting," HBR, Jan-Feb 1986
- Goldhar, Joel D. & Mariann Jelinek. "Plan for Economies of Scope," HBR November-December 1983.
- Hamel, Gary & Prahalad, C.K. "Strategic Intent," HBR, July – August 2005.
- Harvard Management Update, "Should You Be Using Simulations?" June 2000.
- Kallio, et al. "Drivers and tracers of business changes," Journal of Strategic Information Systems, 8, 1999
- Malhotra, Deepak. "Negotiate or Litigate?" Negotiation, October 2004
- Porter and Millar, "How information gives you competitive advantage," HBR, July 85. (value chain article).
- Porter, "How competitive forces shape strategy," HBR, March 1979.
- Quinn, James Brian. "Technological Forecasting," HBR, March-April 1967.
- Raynor, Michael & Jil Panetta. "A Better Way to R&D?" Strategy & Innovation, March – April, 2005.
- Ring, Peter Smith, Doz, Yves L., & Olk, Paul M. "Managing Formation Processes in R&D Consortia," CMR, Vol. 47, No. 4, Summer 2005.
- Sirkin, Harold, Keenan, Perry, & Alan Jackson. "The Hard Side of Change Management," HBR, Oct 2005
- Sobek, et al. "Another Look at How Toyota Integrates Product Development," HBR, July-August 1998.
- Spear, Steven & Bowen, H. Kent, "Decoding the DNA of the Toyota Production System," HBR, Sept – Oct 1999
- Sterman, John D., "System Dynamics Modeling: Tools for Learning in a Complex World," CMR, Vol. 43, Num. 4, Summer 2001.
- Susskind, Lawrence, "Full Engagement: Learning the Most from Negotiation Simulations," Negotiation, August 2005
- Thomke, "Simulation, learning and R&D performance," Research Policy 27 (1998)
- Thomke, "Capturing the Real Value of Innovation Tools," MIT Sloan Management Review, Winter 2006
- Thomke, "Enlightened Experimentation: The New Imperative for Innovation," HBR, Feb 2001.

- Thomke, Stefan & Hippel, Eric von, “Customers as Innovators: A New Way to Create Value,” HBR April 2002.
- Ward, et al. “The Second Toyota Paradox,” Sloan Management Review, Spring 1995.
- Christensen, Clayton M. (1997) The Innovator’s Dilemma
- Schrage, Michael (2000) Serious Play
- Thomke, Stefan (2003) Experimentation Matters

### *Course Learning Objectives*

Students who have successfully completed this course will be able to:

1. Recognize logical fallacies in the inconsistent in the use of commercial acquisition strategies (ESR A2.1)
2. Synthesize M&S concepts to anticipate benefits to commercial aircraft industry (ESR A2.2)
3. Analyze, compare and contrast applications of M&S in various commercial automotive industry (ESR A2.3)
4. Evaluate the application of M&S to the commercial Pharmaceutical industry (ESR A2.4)
5. Appraise possible change management approaches associated with M&S adoption (ESR A2.5)
6. Appraise possible impacts of emerging CASE tool technologies and their contribution to corporate integration (ESR A2.6)

### *Course Assessment Plan*

Verbal Feedback during Class- to periodically check on students’ understanding of topics taught

Term Papers- research-based projects to test students’ ability to synthesize knowledge and draw conclusions based on knowledge learnt in class

Lab-based Project- open-ended practical project to test students’ hands-on and cognitive ability to design experiments and demonstrate M&S software applications

End-of-Course Evaluation- open-ended and closed questions to test student’s tacit knowledge in subject matter

### *Hour-by-hour Instruction*

Hour 1 and 2: ESR A2.1: Overview of commercial acquisition strategies and terminology, Syllabus

Hour 3 through 8: ESR A2.2: Introduction to M&S benefits to commercial aircraft  
Commercial case history of HOW M&S has been used to advance and sustain quality and distribute production world-wide by global commercial aircraft manufacturers from the foundation of aviation with the Wright brothers to the most current aircraft.

\*Porter, HBR, March 1979

- \*Fuchs, et al CMR 2000
- \*Porter and Millar, HBR, July 85.
- \*Hamel & Prahalad, HBR, 2005
- \*HBR Case 9-305-101;
- \*Quinn, HBR 1967;
- \*Chambers, et al., HBR 1971;
- \*Georgoff & Murdick, HBR 1986
- \*HBS Case 9-688-040

Hour 9 and 10: ESR A2.2: Student group Aviation Case History research and presentation

Hour 11 and 22: ESR A2.3: Introduction to M&S benefits to commercial automotive industries. Commercial case history of recent radical changes in HOW M&S has been used by a Global Automotive Company to radically alter their entire software infrastructure, re-train their work force, rapidly close and then surpass other Global Automotive Commercial Companies through the productivity and time to market gains made possible through M&S

- \*HBS Case 9-602-035;
- \*Morgan, James M. and Liker, Jeffrey K., (2006) The Toyota Product Development System
- \*Ward, et al, Sloan Management Review, Spring 1995;
- \*Sobek, Liker & Ward, HBR July-August 1998;
- \*Spear & Bowen, HBR, 1999
- \*Thomke, MIT, 2006
- \*Thomke, HBR, 2001
- \*HBS Case 9-699-044 & 045
- \*HBS Case 9-303-023
- \*Thomke, Research Policy 27 (1998) 55-74;
- \*Goldhar & Jelink, HBR, 1983

Hour 23 through 25: ESR A2.3: Individual independent research project reports and presentations on automotive industry.

Hour 26 and 28: ESR A2.4: Introduction to M&S benefits to commercial Pharmaceutical industries,

- \*HBS 9-600-038
- \*Raynor & Panetta, S&I, 2005
- \*Sterman, CMR, 2001
- \*Ring et al, CMR, 2005

Hour 29 through 32: ESR A2.5: Commercial case history of change management issues and approaches as it relates to M&S adoption and proliferation. Change management due to M&S tool adoption (45 hour course would have a 3 hour Student report and presentation)

- \*Susskind, Negotiation, 2005

- \*Harvard Update, 2000
- \*Bonabeau, 2002
- \*Kallio, et al Journal, 1999
- \*Sirkin, et al, HBR, 2005
- \*Malhotra, Negotiation, 2004

Hour 35 and 36: ESR A2.6: Commercial case history of the use of Computer Assisted System Engineering tools to describe the relationship within and between systems life cycles within a corporation and close gaps between those systems. Change emerging trends in CASE tool applications, Sectional Review, Conclusion, End-of-Course Test (45 hour course would have a 3 hour Student report and presentation)

\*Contemporary articles

*\*Note the above syllabus is a best estimate for time, content, and references at the time of writing and is subject to change at any time.*

---

Course Name: Computer Technology and Army Training Modeling and Simulation (M&S) Applications in Support of Acquisition

*Course Coordinator:*

Michael D. Proctor, Ph.D., LTC (Retired)

Associate Professor, CMSP

IEMS & IDS M&S

University of Central Florida

Engineering Building 2, Room 301-D

Tel: 407-823-5296

Fax: 407-823-3413

[mproctor@mail.ucf.edu](mailto:mproctor@mail.ucf.edu)

<http://people.cecs.ucf.edu/proctor>

*Course Description:*

This course seeks to provide an *educational mastery* (a masters level course that is part of a masters program in modeling and simulation) of essential skill requirements of basic computer system software tools and Army Training Modeling and Simulation applications that are used in support of acquisition. Exposure to practical Army training modeling and simulation (M&S) applications as system life cycle management tools in support of Simulation-based Acquisition (SBA) will be through cases.

*Modules incorporated into Course:*

This course incorporates ESR A2 material covered in the Awareness, Understanding, and Application courses (modules) and will reuse the Awareness level online course learning module if developed.

*ESR Supporting the Course*

ESR E8. Sub ESR taught at Educational Mastery (part of a masters program) competency level or at the maximum level specified in the matrix.

*Pre-requisite*

1. Rank/Seniority:

Active Military: O-3 and above

Government Civilian: GS-9 and above

2. Pre-Course/Training:

CLE011 and CLE023 or equivalent

*Course Maturity*

New course.

*Contact Hours / Pace of Completion*

This is a quarter or semester-long (12 to 15 weeks) course with 36 to 45 contact hours with 3hr-instruction per week. Alternatively the course may be accomplished in a shorter period of time covering the same number of contact hours but with a faster paced setting being 6 hours per week.

*Proposed Delivery Modality*

The course is a mixture of face-to-face teaching and will reuse the Awareness level online course learning module if the online course (module) is developed.

*Proposed Reference and Text*

- Case Study to be developed with PEO STRI on Live Training Simulation in Acquisition (OneTESS)
- Case Study to be developed with PEO STRI on Constructive Training Simulation in Acquisition (OneSAF Objective System)
- Case Study to be developed with IBM on Rational
- OUSD (AT&L) (2006). *Acquisition Modeling and Simulation Master Plan*. Department of Defense.
- Piplani Lalik, Mercer Joseph, Roop Richard (1994). *Systems Acquisition Manager's Guide for the Use of Models and Simulations*. Defense Systems Management College.
- Proctor (Editor) (1999) *Web-based Technical Reference on Simulation Interoperability*
- Proctor Michael, Posey-Macalintal Amy, Kulonda Dennis (2003). *Why the "T" in SMART: A Constructive Synergy*. Acquisition Review Quarterly Summer 2003: 285-299
- Proctor Michael, Lipinski Michael (2000). Technical Performance Measures and Distributed-Simulation Training Systems. Acquisition Review Quarterly Winter 2000: 19-32
- Sherman William, Craig Alan (2003). *Understanding Virtual Reality*. Morgan Kaufman Publishers.

- Woodridge Michael (2002). *Multiagent Systems*. John Wiley & Sons.

### *Course Learning Objectives*

Students who have successfully completed this course will be able to:

1. ESR E8.1 Compare and contrast basic computer system architecture, operating systems, networking, introductory engineering software and their application to Modeling and Simulation (M&S) applications, introductory structured programming languages such as Fortran and C, and the use of such languages for software development
2. ESR E8.2 Compare and contrast the use of selected Modeling and Runtime software systems to build M&S scenarios to support PMs, SEs, and T&E requirements across the acquisition life cycle.
3. ESR E8.3 Compare and Contrast the use of selected Intelligent Agent software systems to build M&S scenarios to support PMs, SEs, and T&E requirements across the acquisition life cycle.
4. ESR E8.4 Compare and Contrast M&S, interoperability, and intelligent agent software tools to build massively online systems (to include gaming systems) so as to support PMs, SEs, and T&E requirements across the acquisition life cycle.
5. ESR E8.5 Compare and Contrast alternative Live training M&S systems in support of training and T&E requirements across the acquisition life cycle.
6. ESR E8.6 Compare and Contrast alternative virtual training M&S systems in support PMs, SEs, and T&E requirements across the acquisition life cycle.
7. ESR E8.7 Compare and Contrast Computer Assisted System Engineering tools to support project life cycle development/engineering.

### *Course Assessment Plan*

Verbal Feedback during Class- to periodically check on students' understanding of topics taught

Term Papers- research-based projects to test students' ability to synthesize knowledge and draw conclusions based on knowledge learnt in class

Lab-based Project- open-ended practical project to test students' hands-on and cognitive ability to design experiments and demonstrate M&S software applications

End-of-Course Evaluation- open-ended and closed questions to test student's tacit knowledge in subject matter

### *Hour-by-hour Instruction*

Hour 1: Compare and contrast basic computer systems, M&S tools for acquisition (E8.1)

Hour 2: Compare and contrast Modeling Software Authoring for acquisition (E8.2)



Hour 3: Compare and contrast Runtime Software for acquisition (Presagis Vega and AIS SVS) (The 45 hour course would have 3 hours on each topic) (E8.2)

Hour 4: Compare and contrast Intelligent Agent Software for acquisition (OneSAF, Mak VR Forces, SimBionic) (E8.3)

Hour 5: Compose M&S Software with Authoring Tools (E8.2 & E8.3)

Hour 6: Compose M&S Software with Authoring Tools (E8.2 & E8.3)

Hour 7: Infers Lab-based Acquisition Evaluation- Experimental Design with Authoring Tools (E8.2 & E8.3)

Hour 8: Infers Lab-based Acquisition Evaluation- Experimental Design with Authoring Tools (E8.2 & E8.3)

Above 8 hours supported by:

Case Study to be developed with PEO STRI on Constructive Training Simulation in Acquisition (OneSAF Objective System)

Piplani Lalik, Mercer Joseph, Roop Richard (1994). *Systems Acquisition Manager's Guide for the Use of Models and Simulations*. Defense Systems Management College.

OUSD (AT&L) (2006). *Acquisition Modeling and Simulation Master Plan*. Department of Defense.

Proctor (Editor) (1999) *Web-based Technical Reference on Simulation Interoperability*

Sherman William, Craig Alan (2003). *Understanding Virtual Reality*. Morgan Kaufman Publishers.

Woodridge Michael (2002). *Multiagent Systems*. John Wiley & Sons.

Hour 9: Compare and contrast massively online M&S Systems to include games for acquisition (E8.4)

Hour 10: Compose massively scenario with Online system (E8.4)

Hour 11: Compose massively scenario with Online system (E8.4)

Hour 12: Compose massively scenario with Online system (E8.4)

Hour 13: Infer Lab-based Acquisition Evaluation- Experimental Design with Online Systems (E8.4)

Hour 14: Infer Lab-based Acquisition Evaluation- Experimental Design with Online Systems (E8.4) (45 hour course would have one additional hour)

Above 6 hours supported by:

Proctor (Editor) (1999) *Web-based Technical Reference on Simulation Interoperability*

Sherman William, Craig Alan (2003). *Understanding Virtual Reality*. Morgan Kaufman Publishers.

Woodridge Michael (2002). *Multiagent Systems*. John Wiley & Sons.

Hour 15: Diagram SMART Snake Chart Structure and Concept for Live Training M&S for acquisition (E8.5)

Hour 16: Compare and Contrast Live Training M&S for Acquisition (OneTESS) (E8.5)

Hour 17: Analyze Live Training M&S Case Study (OneTESS) (E8.5)

Above 3 hours supported by:

Case Study to be developed with PEO STRI on Live Training Simulation in Acquisition (OneTESS)

Hour 18: Diagram SMART Snake Chart Structure and Concept for Virtual Training M&S for acquisition (E8.6)

Hour 19: Compare and Contrast Virtual Training M&S for Acquisition (CCTT) (E8.6)

Hour 20: Analyze Virtual Training M&S Case Study (CCTT) (E8.6)

Above 3 hours supported by:

Proctor Michael, Posey-Macalintal Amy, Kulonda Dennis (2003). *Why the "T" in SMART: A Constructive Synergy*. Acquisition Review Quarterly Summer 2003: 285-299

Proctor Michael, Lipinski Michael (2000). Technical Performance Measures and Distributed-Simulation Training Systems. Acquisition Review Quarterly Winter 2000: 19-32

Hour 21: Discuss with Guest Lecture Live, Virtual, and Constructive Training simulation use for acquisition (E8.2, E8.5 and E8.6)

Hour 22: Discuss with Guest Lecture Live, Virtual, and Constructive Training simulation use for acquisition (E8.2, E8.5 and E8.6)

Hour 23: Discuss with Guest Lecture Live, Virtual, and Constructive Training simulation use for acquisition (E8.2, E8.5 and E8.6)

Above 3 hours to be supported with

Case Study to be developed with PEO STRI on Constructive Training Simulation in Acquisition (OneSAF Objective System)

Case Study to be developed with PEO STRI on Live Training Simulation in Acquisition (OneTESS)

Proctor Michael, Posey-Macalintal Amy, Kulonda Dennis (2003). *Why the "T" in SMART: A Constructive Synergy*. Acquisition Review Quarterly Summer 2003: 285-299

Proctor Michael, Lipinski Michael (2000). Technical Performance Measures and Distributed-Simulation Training Systems. Acquisition Review Quarterly Winter 2000: 19-32

Hour 24: Compare and Contrast Computer Assisted System Engineering software (E8.7)

Hour 25: Compose Computer Aided System Engineering Case Study (E8.7)

Hour 26: Compose Computer Aided System Engineering Case Study (E8.7) (45 hour course would have 3 additional hours)

Hour 27: Infer Lab-based System Acquisition with Computer-Aided System Engineering Tools (E8.7)

Hour 28: Infer Lab-based System Acquisition with Computer-Aided System Engineering Tools (E8.7)

Hour 29: Infer Lab-based System Acquisition with Computer-Aided System Engineering Tools (E8.7)

Above 6 hours supported by  
Case Study to be developed with IBM on Rational

Hour 30 - 35: Student Term Paper Presentation and Sharing (All ESRs and references)

Hour 36: Conclusion and End-of-Course Evaluation

*\* Note the above syllabus is a best estimate for time, content, and references at the time of writing and is subject to change at any time.*

**A3) Evaluate M&S proposals, relative to measurable program contributions, and decide on the appropriate program office level of expenditure on M&S tools throughout the program life cycle. Distinguish whether custom or off-the-shelf products will be best suited for the program's purpose.**

- 1) Module name: M&S Proposals
- 2) Module coordinator: Marsha Taliaferro-Gillis, Ph.D.  
6596 Main Street  
Gloucester, VA 23061  
(804)694-3173 (Office)  
(804) 824 4663 (Cell)  
mtgillis@werneranderson.com
- 3) Module description: Be able to discern among M&S proposals, relative to measurable program contributions, and decide on the appropriate program office level of expenditure on M&S tools throughout the program life cycle. Distinguish whether custom or off-the-shelf products will be best suited for the program's purpose.
- 4) ESRs that the module supports: A3
- 5) Prerequisites assumed, and corresponding level of mastery:
- 6) Module maturity: none
- 7) Number of hours estimated to teach module: 20 (1 hour of introduction and overview)
- 8) Proposed Delivery modality: face-to-face, on-line, VTC, resident, customer's site
- 9) Proposed references and texts:

Department of the Army. 2005. *Simulation Support Planning and Plans*. (DA PAM 5-12) [http://www.army.mil/usapa/epubs/pdf/p5\\_12.pdf](http://www.army.mil/usapa/epubs/pdf/p5_12.pdf)

DoD. 2004. *Defense Acquisition Guidebook*. <https://akss.dau.mil/dag/>

DoD. 1994. *DoD Directive 5000.59 Modeling and Simulation Management*. <https://www.dmsomil/public/library/policy/policy/d500059p.pdf>

DoD. 2006. *VV&A Recommended Practices Guide*. <http://vva.dmsomil/>

Rubenstein, R. Y., B. Melamel. 1998. *Modern Simulation and Modeling*. John Wiley and Sons, Inc., New York, NY.

## 10) Module learning objectives:

- A3.1 Define the role of M&S throughout the acquisition cycle (e.g., Concept Development, DT&E, OT&E, LFT&E, and operations and sustainment)
- A3.2 Describe the use of an M&S Support Plan throughout the acquisition cycle.
- A3.3 Define and distinguish between legacy, developmental, GOTS and COTS M&S.
- A3.4 Understand the V&V process and its impact on M&S usage, acceptability, and cost.
- A3.5 Understand the benefit and application of M&S reuse across programs and across a single program's lifecycle.
- A3.6 Apply a sample M&S Support Plan to provide best use of M&S across all stages of the acquisition life-cycle.
- A3.7 Given a case study and sample M&S Support Plan, develop an M&S budget.
- A3.8 Given a case study and sample M&S Support Plan, select between available legacy, developmental, GOTS and COTS M&S options.

## 11) Course assessment plan: Projects and Exams

## 12) Topic list by hour of instruction and reference

*Competency Level: General Awareness*

- i) Hour 1: Introduction and Overview (course notes and syllabus)
  - DoD. 2004. *Defense Acquisition Guidebook*.  
<https://akss.dau.mil/dag/>

*Competency Level: General Awareness*

- ii) Hour 2: The Role of M&S in Concept Development and DT&E (A3.1)
  - DoD. 2004. *Defense Acquisition Guidebook*.  
<https://akss.dau.mil/dag/>

*Competency Level: General Awareness*

- iii) Hour 3: The Role of M&S in OT&E, LFT&E, and Operations and Sustainment (A3.1)
  - DoD. 2004. *Defense Acquisition Guidebook*.  
<https://akss.dau.mil/dag/>

*Competency Level: General Awareness*

- iv) Hour 4: The Modeling and Simulation Support Plan (A3.2)
  - DoD. 2004. *Defense Acquisition Guidebook*.  
<https://akss.dau.mil/dag/>
  - Department of the Army. 2005. *Simulation Support Planning and Plans*. (DA PAM 5-12)  
[http://www.army.mil/usapa/epubs/pdf/p5\\_12.pdf](http://www.army.mil/usapa/epubs/pdf/p5_12.pdf)

*Competency Level: General Awareness*

- v) Hour 5: The MSSP; Requirements Across the Services and Best Practices (A3.2)

- Department of the Army. 2005. *Simulation Support Planning and Plans*. (DA PAM 5-12)  
[http://www.army.mil/usapa/epubs/pdf/p5\\_12.pdf](http://www.army.mil/usapa/epubs/pdf/p5_12.pdf)

*Competency Level: General Awareness*

- vi) Hour 6: M&S Types and Sources (A3.3)

- Rubenstein, R. Y., B. Melamel. 1998. *Modern Simulation and Modeling*. John Wiley and Sons, Inc., New York, NY.

*Competency Level: General Awareness*

- vii) Hour 7: Verification and Validation Overview (A3.4)

- DoD. 2006. *VV&A Recommended Practices Guide*.  
<http://vva.dmsomil/>

*Competency Level: Understanding*

- viii) Hour 8: V&V and M&S application, acceptability and cost (A3.4)

- DoD. 2006. *VV&A Recommended Practices Guide*.  
<http://vva.dmsomil/>

*Competency Level: Understanding*

- ix) Hour 9: V&V and M&S application, acceptability and cost (A3.4)

- DoD. 2006. *VV&A Recommended Practices Guide*.  
<http://vva.dmsomil/>

*Competency Level: General Awareness*

- x) Hour 10: M&S Use and Re-use Across Single Program Lifecycle (A3.5)

- DoD. 2004. *Defense Acquisition Guidebook*.  
<https://akss.dau.mil/dag/>
- DoD. 1994. DoD Directive 5000.59 *Modeling and Simulation Management*.  
<https://www.dmsomil/public/library/policy/policy/d500059p.pdf>

*Competency Level: Understanding*

- xi) Hour 11: M&S Use and Re-use Across Multiple Programs (A3.5)

- DoD. 2004. *Defense Acquisition Guidebook*.  
<https://akss.dau.mil/dag/>
- DoD. 1994. DoD Directive 5000.59 *Modeling and Simulation Management*.  
<https://www.dmsomil/public/library/policy/policy/d500059p.pdf>

*Competency Level: General Awareness*

- xii) Hour 12: MSSP Application Project (A3.6)
- DoD. 2004. *Defense Acquisition Guidebook*.  
<https://akss.dau.mil/dag/>
  - DoD. 1994. DoD Directive 5000.59 *Modeling and Simulation Management*.  
<https://www.dmsso.mil/public/library/policy/policy/d500059p.pdf>

*Competency Level: Understanding*

- xiii) Hour 13: MSSP Application Project (A3.6)
- DoD. 2004. *Defense Acquisition Guidebook*.  
<https://akss.dau.mil/dag/>
  - DoD. 1994. DoD Directive 5000.59 *Modeling and Simulation Management*.  
<https://www.dmsso.mil/public/library/policy/policy/d500059p.pdf>

*Competency Level: Application*

- xiv) Hour 14: MSSP Application Project (A3.6)
- DoD. 2004. *Defense Acquisition Guidebook*.  
<https://akss.dau.mil/dag/>
  - DoD. 1994. DoD Directive 5000.59 *Modeling and Simulation Management*.  
<https://www.dmsso.mil/public/library/policy/policy/d500059p.pdf>

*Competency Level: Application*

- xv) Hour 15: MSSP Application Project (A3.6)
- DoD. 2004. *Defense Acquisition Guidebook*.  
<https://akss.dau.mil/dag/>
  - DoD. 1994. DoD Directive 5000.59 *Modeling and Simulation Management*.  
<https://www.dmsso.mil/public/library/policy/policy/d500059p.pdf>

*Competency Level: Mastery*

- xvi) Hour 16: MSSP and M&S Budget Project (A3.7)
- DoD. 2004. *Defense Acquisition Guidebook*.  
<https://akss.dau.mil/dag/>
  - DoD. 1994. DoD Directive 5000.59 *Modeling and Simulation Management*.  
<https://www.dmsso.mil/public/library/policy/policy/d500059p.pdf>

*Competency Level: Mastery*

- xvii) Hour 17: MSSP and M&S Budget Project (A3.7)
- DoD. 2004. *Defense Acquisition Guidebook*.  
<https://akss.dau.mil/dag/>
  - DoD. 1994. DoD Directive 5000.59 *Modeling and Simulation Management*.  
<https://www.dmsomil/public/library/policy/policy/d500059p.pdf>

*Competency Level: Mastery*

- xviii) Hour 18: MSSP and M&S Budget Project (A3.7)
- DoD. 2004. *Defense Acquisition Guidebook*.  
<https://akss.dau.mil/dag/>
  - DoD. 1994. DoD Directive 5000.59 *Modeling and Simulation Management*.  
<https://www.dmsomil/public/library/policy/policy/d500059p.pdf>

*Competency Level: Mastery*

- xix) Hour 19: MSSP and M&S Selection Project (A3.8)
- DoD. 2004. *Defense Acquisition Guidebook*.  
<https://akss.dau.mil/dag/>
  - DoD. 1994. DoD Directive 5000.59 *Modeling and Simulation Management*.  
<https://www.dmsomil/public/library/policy/policy/d500059p.pdf>

*Competency Level: Master*

- xx) Hour 20: MSSP and M&S Selection Project (A3.8)
- DoD. 2004. *Defense Acquisition Guidebook*.  
<https://akss.dau.mil/dag/>
  - DoD. 1994. DoD Directive 5000.59 *Modeling and Simulation Management*.  
<https://www.dmsomil/public/library/policy/policy/d500059p.pdf>



**A4) Recognize contracting issues for M&S products. Include considerations for intellectual property issues, delivery terms, maintenance responsibility, standards for documentation, open architecture, interoperability, reuse and other considerations.**

- 1) Module name: M&S in the Contract Proposal Process
- 2) Module coordinator: Marsha Taliaferro-Gillis, Ph.D.  
6596 Main Street  
Gloucester, VA 23061  
(804)694-3173 (Office)  
(804)824-4663 (Cell)  
mtgillis@werneranderson.com
- 3) Module description: A4) Recognize contracting issues for M&S products. Include considerations for intellectual property issues, delivery terms, maintenance responsibility, standards for documentation, open architecture, interoperability, reuse and other considerations
- 4) ESRs that the module supports: A4
- 5) Prerequisites assumed, and corresponding level of mastery:
- 6) Module maturity: none
- 7) Number of hours estimated to teach: 18 (1 hour of introduction and overview)
- 8) Proposed Delivery modality: face-to-face, on-line, VTC, resident, customer's site
- 9) Proposed references and texts:

DoD. 1993. *Procedures for the Acquisition and Management of Technical Data* (5010.12-M).

DoD. 2004. *Defense Acquisition Guidebook*. <https://akss.dau.mil/dag/>

DoD Office of Acquisition Initiatives. 2001. *Intellectual Property: Navigating Through Commercial Waters*.  
<http://www.acq.osd.mil/dpap/specificpolicy/intelprop.pdf>

Department of the Navy. 2006. *Naval Open Architecture Contract Guidebook*.  
<https://acc.dau.mil/oa>

Kuhl, F., R. Weatherly, J. Dahmann, *Creating Computer Simulation Systems: An Introduction to the High Level Architecture*. Prentice-Hall, Saddle River, NJ, 2000

## 10) Module learning objectives:

- A4.1 Describe the Intellectual Property issues that arise when contracting for M&S products.
- A4.2 Describe and differentiate between possible Terms of Delivery when contracting for M&S products.
- A4.3 Identify the content, format, and medium the government should require for documentation deliverables.
- A4.4 Understand the long-term maintenance options available to government customers when contracting for M&S products.
- A4.5 Understand issues in using Open Architecture products, including compatibility and continued use of legacy or unsupported systems.
- A4.6 Understand the contract process for issuing M&S requirements and insuring that contractor M&S is interoperable with government and other third-party M&S.
- A4.7 Understand the contractual issues involved with re-use of purchased M&S products.
- A4.8 Understand the options and procedures for enforcing contract terms or resolving contractor disputes with regard to M&S.
- A4.9 Given a case study, assess and revise contract documents to insure that program M&S objectives with regard to IP, delivery, interoperability, maintenance, and reuse are met and enforced.

## 11) Course assessment plan: projects, and exams

## 12) Topic list by hour of instruction and reference.

*Competency Level: General Awareness*

- i) Hour one: Introduction and Overview (course notes and syllabus)
  - (i) DOD Office of Acquisition Initiatives. 2001. *Intellectual Property: Navigating Through Commercial Waters*  
<http://www.acq.osd.mil/dpap/specificpolicy/intelprop.pdf>

*Competency Level: General Awareness*

- ii) Hour two: Intellectual Property Issues in Contracting for M&S products. (A4.1)
  - (i) DOD Office of Acquisition Initiatives. 2001. *Intellectual Property: Navigating Through Commercial Waters*  
<http://www.acq.osd.mil/dpap/specificpolicy/intelprop.pdf>

*Competency Level: Understanding*

- iii) Hour three: Intellectual Property Issues in Contracting for M&S products. (A4.1)
  - (i) DoD Office of Acquisition Initiatives. 2001. *Intellectual Property: Navigating Through Commercial Waters*  
<http://www.acq.osd.mil/dpap/specificpolicy/intelprop.pdf>

*Competency Level: General Awareness*

- iv) Hour four: Terms of Delivery and Contracting for M&S products. (A4.2)
  - (i) DoD. 2004. *Defense Acquisition Guidebook*.  
<https://akss.dau.mil/dag/>

*Competency Level: Understanding*

- v) Hour five: Terms of Delivery and Contracting for M&S products. (A4.2)
  - (i) DoD. 2004. *Defense Acquisition Guidebook*.  
<https://akss.dau.mil/dag/>

*Competency Level: Understanding*

- vi) Hour six: Documentation Deliverables. (A4.3)
  - (i) DoD. 1993. *Procedures for the Acquisition and Management of Technical Data* (5010.12-M).

*Competency Level: General Awareness*

- vii) Hour seven: Long-term Maintenance for Contracted M&S products. (A4.4)
  - (i) DoD. 2004. *Defense Acquisition Guidebook*.  
<https://akss.dau.mil/dag/>

*Competency Level: Understanding*

- viii) Hour eight: Long-term Maintenance for Contracted M&S products. (A4.4)
  - (i) DoD. 2004. *Defense Acquisition Guidebook*.  
<https://akss.dau.mil/dag/>

*Competency Level: General Awareness*

- ix) Hour nine: Issues for using Open Architecture. (A4.5)
  - (i) DoD. 2004. *Defense Acquisition Guidebook*.  
<https://akss.dau.mil/dag/>
  - (ii) Department of the Navy. 2006. *Naval Open Architecture Contract Guidebook*. <https://acc.dau.mil/oa>

*Competency Level: Understanding*

- x) Hour ten: Issues for using Open Architecture. (A4.5)
  - (i) DoD. 2004. *Defense Acquisition Guidebook*.  
<https://akss.dau.mil/dag/>
  - (ii) Department of the Navy. 2006. *Naval Open Architecture Contract Guidebook*. <https://acc.dau.mil/oa>

*Competency Level: General Awareness*

- xi) Hour eleven: Insuring Interoperability. (A4.6)
  - (i) Kuhl, F., R. Weatherly, J. Dahmann, *Creating Computer Simulation Systems: An Introduction to the High Level Architecture*. Prentice-Hall, Saddle River, NJ, 2000

- (ii) Department of the Navy. 2006. *Naval Open Architecture Contract Guidebook*. <https://acc.dau.mil/oa>

*Competency Level: Understanding*

- xiii) Hour twelve: Insuring Interoperability. (A4.6)
  - (i) Kuhl, F., R. Weatherly, J. Dahmann, *Creating Computer Simulation Systems: An Introduction to the High Level Architecture*. Prentice-Hall, Saddle River, NJ, 2000
  - (ii) Department of the Navy. 2006. *Naval Open Architecture Contract Guidebook*. <https://acc.dau.mil/oa>

*Competency Level: Understanding*

- xiii) Hour thirteen: Planning for Re-use. (A4.7)
  - (i) DoD. 2004. *Defense Acquisition Guidebook*. <https://akss.dau.mil/dag/>

*Competency Level: Understanding*

- xiv) Hour fourteen: Enforcing M&S Contract Terms. (A4.8)
  - (i) DoD. 2004. *Defense Acquisition Guidebook*. <https://akss.dau.mil/dag/>

*Competency Level: Understanding*

- xv) Hour fifteen: M&S Contract Project. (A4.9)

*Competency Level: Application*

- xvi) Hour sixteen: M&S Contract Project. (A4.9)

*Competency Level: Mastery*

- xvii) Hour seventeen: M&S Contract Project. (A4.9)

*Competency Level: Mastery*

- xviii) Hour eighteen: M&S Contract Project. (A4.9)

**A5) Know where to find organizational M&S resources to identify the number and types of models currently in use, best practices from case studies, where they originated, how they might be leveraged in support of an acquisition program.**

- 1) Title: M&S Organizations and Resources
- 2) Module coordinator: Jim Campbell, GMU, [jcampbell@alionscience.com](mailto:jcampbell@alionscience.com), 703-933-3356
- 3) Module description (short description) At the completion of this module, students will be able to describe the DTIC Information Analysis Center program, the MSIAC in particular, and other M&S resources available to assist them in their various M&S efforts. Taught to the Application Level; for courses at the understanding or general awareness level, time can be reduced and the practical application period deleted.
- 4) ESR supported: A5— Know where to find organizational M&S resources to identify the number and types of models currently in use, best practices from case studies, where they originated, how they might be leveraged in support of an acquisition program.
- 5) Prerequisites: None.
- 6) Module maturity: An over view of the MSIAC is taught in the Modeling and Simulation Staff Officer's Course, the Army's Simulation Operations Qualification Course, and the GMU CPE course, but the material is at the general awareness level.
- 7) Number of hours: Three.
- 8) Proposed Delivery: face-to-face, or VTC; resident, or customer's site
- 9) Proposed references and texts:
  - a) DoD Directive 5000.59, DoD Modeling and Simulation (M&S) Management, 8 August 2007
  - b) Department of Defense Acquisition Modeling and Simulation Master Plan, 17 April, 2006
  - c) Deputy Under Secretary of Defense (Science and Technology), "Charter For The Modeling and Simulation Information Analysis Center," July 15, 1999
  - d) DoD Instruction 3200.14, "Principles and Operational Parameters of the DoD Scientific and Technical Information Program," Enclosure 5 "DoD Information Analysis Centers (IACs), May 13 1997

- e) AR 5-11, Management of Army Models & Simulations, 1 February 2005
- f) OPNAVINST 5200.34, Navy Modeling and Simulation (M&S) Management, 28 May 2002
- g) AFPD 16-10 Modeling And Simulation (M&S) Management, 30 January 1995

10) Module learning objectives:

- A5.1: Identify the DoD and service M&S structure and organizations
- A5.2: Describe the M&S Communities
- A5.3: Describe the role of the M&S Information Analysis Center (MSIAC)
- A5.4: Describe the role of the MSIAC helpdesk and how to contact it for information
- A5.5: List the M&S Coordination Agents
- A5.6: List other M&S resources

11) Course assessment plan: Examination and practical exercise.

12) Topic list by hour of instruction and reference:

- i) Hour one: M&S communities and resources (course notes and syllabus) A5.1, A5.2, A5.5, A5.6
- ii) Hour two: MSIAC (course notes and syllabus) A5.3, A5.4
- iii) Hour three: Examination and summary (course notes and syllabus) A5 all

13) Additional Requirements: This module requires student access to computers and internet connections.

**A6) Access of the Modeling and Simulation Resource Repository as a primary source for information about and access to DoD models, simulations, data sources, algorithms, and other M&S resources in order to facilitate reuse and avoid duplication.**

- 1) Title: The Modeling and Simulation Resource Repositories
- 2) Module coordinator: Jim Campbell, GMU, [jcampbell@alionscience.com](mailto:jcampbell@alionscience.com), 703-933-3356
- 3) Module description (short description) At the completion of this module, students will be able to navigate the DoD MSRR and other service and agency MSRRs and conduct research on M&S information within the MSRRs, supporting the sharing of information and M&S reuse. Taught to the Application Level; for courses at the understanding or general awareness level, time can be reduced and the practical application period deleted.
- 4) ESR supported: A6— Access the Modeling and Simulation Resource Repository as a primary source for information about and access to DoD models, simulations, data sources, algorithms, and other M&S resources in order to facilitate reuse and avoid duplication.
- 5) Prerequisites: ESR A5.
- 6) Module maturity:  
An overview of the MSRR is taught in the Modeling and Simulation Staff Officer's Course and in the Army's Simulation Operations Qualification Course.
- 7) Number of hours: Three.
- 8) Proposed Delivery: Face-to-face, or VTC; resident, or customer's site
- 9) Proposed references and texts:  
  
DoD 5000.59-P, Department of Defense Modeling and Simulation (M&S) Master Plan, October 1995
- 10) Module learning objectives:  
A6.1: Describe the purpose of the MSRR  
A6.2: Demonstrate proficiency in logging on to the various MSRRs  
A6.3: Locate information in the MSRR for a specific model, simulation, data source, algorithm, or resource  
A6.4: Describe the DoD philosophy of M&S reuse
- 11) Course assessment plan: Examination and practical exercise.

12) Topic list by hour of instruction and reference:

- i) Hour one: Introduction to the MSRR (MSMP) A6.1, A6.4
- ii) Hour two: Practical application (course notes and syllabus) A6.2, A6.3
- iii) Hour three: Examination and summary (course notes and syllabus) A6 all

13) Additional Requirements: This module requires student access to computers and internet connection.



**A7) Use M&S to make informed engineering tradeoff analyses through the program's Decision Risk Analysis process. Apply experimental design, level of model detail, and M&S application as a pre-test prediction tool. Evaluate the analysis of M&S outputs/measures.**

- 1) Module name: Decision Risk Analysis
- 2) Module coordinator/POC: Anthony Genna  
UCSD Extension  
Assistant Director,  
Defense Technology  
agenna@ucsd.edu  
858-603-2170 (cell)
- 3) Module description: Use M&S to make informed engineering tradeoff analyses through the program's Decision Risk Analysis process. Apply experimental design, level of model detail, and M&S application as a pre-test prediction tool. Evaluate M&S outputs/measures.
- 4) ESRs that the module supports and the corresponding level of mastery:
- 5) Prerequisites assumed, and corresponding level of mastery: training and education (i.e., BS/MS degree or DAU/DoD courses, certifications, etc.) meeting requirements of current position and/or rank/grade/rate.

In addition it is recommended that student have academic training or OJT equivalent to the following levels of competency:

- (1) M&S "GA" module: General Awareness in current job position
- (2) M&S "UN" module: Understanding in current job position
- (3) M&S "AP" module: Application in current job position
- (4) M&S "MA" module: Mastery in current job position
- 6) Module maturity: has it been taught, and if so, a brief history: TBD
- 7) Number of hours estimated to deliver/teach module: 24 Hours
 

(1) General Awareness	3 hours
(2) Understanding	3 hours
(3) Application	8 hours
(4) Mastery	10 hours
- 8) Proposed Delivery modality:  
- Face-to-face, VTC, resident, customer's site.
- 9) Proposed references and texts:

Text will be a current, entry-level M&S text to be identified by the instructor at time of delivery. Additional reference material will include current available literature selected by the instructor for practical application in support of the curriculum. Other supporting text/reference material will be student contributions of relevant material from their experience.

- Simulation Based Acquisition: A New Approach, Report of the Military Research Fellows DSMC 1997-1998

DoDD 5000.1 and DoDI 5000.2 : <https://akss.dau.mil/dapc/TUTORIAL/index.htm>

Defense Acquisition Guidebook:

<https://akss.dau.mil/dag/DoD5000.asp?view=document&doc=2>

Defense Acquisition Policy Center: <https://akss.dau.mil/dapc/index.aspx>

Risk Management Guide for DoD Acquisition

<http://www.sei.cmu.edu/risk/dod-risk.pdf>

10) Module learning objectives: Use M&S to make informed engineering tradeoff analyses through the program's Decision Risk Analysis process. Apply experimental design, level of model detail, and M&S application as a pre-test prediction tool. Evaluate M&S outputs/measures.

A7.1	Demonstrate competency level described in above matrix to develop pre-test criteria and analyze/apply choices of design detail for desired performance factors for a selected application.
A7.2	Demonstrate competency level described in above matrix to analyze outputs/measures from M&S tools for a given case study.
A7.3	Demonstrate competency level described in above matrix to evaluate performance factors and interdependencies of outputs/measures for a given case study.
A7.4	Demonstrate competency level described in above matrix to identify and prioritize risk factors using Decision Risk Analysis process.
A7.5	Demonstrate competency level described in above matrix to perform informed engineering tradeoff analyses through Decision Risk Analysis process.

11) Course assessment plan (projects, exams, papers, etc.)

- Team projects/case studies, discussion, written questions.

12) Topic list by hour of instruction and reference:

The hours of instruction are categorized based on the level of competency required. As a result of this format the hour structure starts at a level of general awareness and progresses

through mastery. This will allow the course material to be easily segmented into each one

Hours	Subject Matter	Ref
1-3	Introduction and overview of informed engineering tradeoff analyses using a Decision Risk Analysis process; introduction and overview of M&S outputs/measures and their application.	Ref [1]
4	Student will demonstrate basic understanding of outputs/measures from M&S tools.	Ref [1]
5	Student will demonstrate basic understanding of identification and prioritization of risk factors using a Decision Risk Analysis process.	Ref [1]
6	Student will demonstrate basic understanding of how a Decision Risk Analysis process enables informed engineering tradeoff analyses.	Ref [1]
7	Student will demonstrate ability to use M&S applications to develop pre-test criteria and analyze/apply choices of design detail for desired performance factors for a selected application.	Ref [1]
8	Student will demonstrate ability to use M&S applications to analyze outputs/measures from M&S tools for a given case study.	Ref [1]
9	Student will demonstrate ability to use M&S applications to evaluate performance factors and interdependencies of outputs/measures for a given case study.	Ref [1]
10-11	Student will demonstrate ability to use M&S applications to identify and prioritize risk factors using Decision Risk Analysis process.	Ref [1]
12-14	Class project: perform informed engineering tradeoff analyses through Decision Risk Analysis process.	Ref [1]
15-16	Student will demonstrate use of M&S tools to support analysis and application of choices of design detail for desired performance factors.	Ref [1]
17-18	Student will demonstrate use of M&S tools in support of analysis of M&S outputs/measures. Includes case study.	Ref [1]
19-20	Student will demonstrate use of M&S tools in support of analysis and evaluation of performance factors and interdependencies of outputs/measures for a given case study.	Ref [1]
21-22	Student will demonstrate use of M&S tools to identify and prioritize risk factors using Decision Risk Analysis process.	Ref [1]
23-24	Class project: Evaluation of informed engineering tradeoff analyses through Decision Risk Analysis process.	Ref [1]

of the 4 levels of competency.

Ref [1] TBD by NPS partners.

**T1) Quantify the risk of using M&S in place of live testing. For open systems, quantify the risk of using M&S to evaluate a single system component in place of testing an entire configuration.**

- 1) Module T1-G M&S and Live Systems (Application)
- 2) Coordinators  
 Dr. Jeffrey S. Strickland, UAH CMSA, 256-824-4415, [jeffrey.strickland@uah.edu](mailto:jeffrey.strickland@uah.edu)  
 Dr. Mikel D. Petty, UAH CMSA, 256-824-4368, [pettym@uah.edu](mailto:pettym@uah.edu)
- 3) Module description This module depicts the training required for a general awareness knowledge level for program managers, system engineers, and T&E workforce members for ESR T1: Quantify the risk of using M&S in place of live testing. For open systems, quantify the risk of using M&S to evaluate a single system component in place of testing an entire configuration.
- 4) ESRs that the module supports and the corresponding level of mastery  
 T1 General Awareness
- 5) Prerequisites assumed, and corresponding level of mastery TST 102, Fundamentals of Test and Evaluation (DAU DL Course)
- 6) Module maturity:
- 7) Number of hours estimated to deliver/teach module 8 hours
- 8) Proposed delivery modality Hybrid CD-ROM and Web-based format
- 9) Proposed references and texts (topics refer to these by number)
  - [1] SSTD TECHEVAL/OPEVAL LESSONS LEARNED, A Study in Test and Evaluation Management, by George Axiotis, NAVSEA T&E Office, March 16, 1998.
  - [2] TERC, GA Tech, T&E Conferences, Second Conference on the Economics of T&E, "Life Cycle Costing and Its Relationship to T&E," Mr. Waynard Devers, Institute for Defense Analyses, 1999
  - [3] Risk and Its Impact on VV&A, Recommended Practices Guide, <http://vva.dmsomil>
  - [4] RISK MANAGEMENT GUIDE FOR DOD ACQUISITION, Sixth Edition (Version 1.0), August, 2006
  - [5] Department of the Army Pamphlet 73-1: Test and Evaluation in Support of Systems Acquisition, Headquarters, Department of the Army, Washington, DC, 30 May 2003.
  - [6] Systems Analysis, Design, and Development, by Charles Wasson, NY: Wiley, 2006
- 10) Module learning objectives

- a) T1.1 Describe the roles, uses, limitations and trends of models and simulations of various types.
  - b) T1.2 Identify how M&S is used in systems engineering and decision support for T&E.
  - c) T1.3 Identify how M&S is used in a system's lifecycle for all phases of test and evaluation.
  - d) T1.4 Identify appropriate simulation use and model fidelity for systems validation.
  - e) T1.5 Identify the restrictions, applications, limitations, and risk reduction of M&S during T&E.
  - f) T1.6 Describe the risks of using M&S to evaluate a single system component in place of testing an entire configuration.
  - g) T1.7 Describe the levels of risk in testing and how M&S can be applied in risk reduction.
  - h) T1.8 Evaluate acceptable risk involving the use of M&S in testing.
  - i) T1.9 Describe the use of M&S for risk analysis and mitigation.
- 11) Course assessment plan It contains an end of module test that must be passed with a 100% score (may be taken as many times as necessary).
- 12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)
- 1. Introduction and overview (course notes and syllabus)
  - 2. Roles, uses, limitations and trends of models and simulations of various types; T1.1; [5]
  - 3. Use of M&S in systems engineering and decision support for T&E; T1.2; [5]
  - 4. Use of M&S in a system's lifecycle for all phases of test and evaluation; T1.3; [5]
  - 5. Appropriate simulation use and model fidelity for systems validation; T1.4; [5]
  - 6. Restrictions, applications, limitations, and risk of using M&S during T&E; T1.5 T1.6; [5]
    - i) Risks of using M&S in evaluating a single system component in place of testing an entire configuration;
    - ii) In conjunction with live testing
    - iii) In test planning
  - 7. Levels of risk in testing; [3]
    - a) M&S applied in risk reduction; T1.7
    - b) Acceptable risk involving the use of M&S in testing; T1.8
  - 8. Use of M&S for risk analysis and mitigation; T1.9; [5]

1) Module T1-U M&S and Live Testing (Understand)

2) Coordinators

Dr. Jeffrey S. Strickland, UAH CMSA, 256-824-4415, [jeffrey.strickland@uah.edu](mailto:jeffrey.strickland@uah.edu)

Dr. Mikel D. Petty, UAH CMSA, 256-824-4368, pettym@uah.edu

- 3) Module description This module depicts the training required for an understanding knowledge level for program managers, system engineers, and T&E workforce members for ESR T1: Quantify the risk of using M&S in place of live testing. For open systems, quantify the risk of using M&S to evaluate a single system component in place of testing an entire configuration.
- 4) ESRs that the module supports and the corresponding level of mastery  
T1 Understanding
- 5) Prerequisites assumed, and corresponding level of mastery TST 203, Intermediate Test and Evaluation (DAU DL Course), and Module T1-G.
- 6) Module maturity
- 7) Number of hours estimated to deliver/teach module 10 hours
- 8) Proposed delivery modality face-to-face/ Hybrid CD-ROM and Web-based format
- 9) Proposed references and texts (topics refer to these by number)  
[1] SSTD TECHEVAL/OPEVAL LESSONS LEARNED, A Study in Test and Evaluation Management, by George Axiotis, NAVSEA T&E Office, March 16, 1998.  
[2] TERC, GA Tech, T&E Conferences, Second Conference on the Economics of T&E, "Life Cycle Costing and Its Relationship to T&E," Mr. Waynard Devers, Institute for Defense Analyses, 1999  
[3] Risk and Its Impact on VV&A, Recommended Practices Guide, <http://vva.dmsomil>  
[4] RISK MANAGEMENT GUIDE FOR DOD ACQUISITION, Sixth Edition (Version 1.0), August, 2006  
[5] Department of the Army Pamphlet 73-1: Test and Evaluation in Support of Systems Acquisition, Headquarters, Department of the Army, Washington, DC, 30 May 2003.  
[6] Systems Analysis, Design, and Development, by Charles Wasson, NY: Wiley, 2006
- 10) Module learning objectives
  - a) T1.1 Describe the roles, uses, limitations and trends of models and simulations of various types.
  - b) T1.2 Identify how M&S is used in systems engineering and decision support for T&E.
  - c) T1.3 Identify how M&S is used in a system's lifecycle for all phases of test and evaluation.
  - d) T1.4 Identify appropriate simulation use and model fidelity for systems validation.

- e) T1.5 Identify the restrictions, applications, limitations, and risk reduction of M&S during T&E.
- f) T1.6 Describe the risks of using M&S to evaluate a single system component in place of testing an entire configuration.
- g) T1.7 Describe the levels of risk in testing and how M&S can be applied in risk reduction.
- h) T1.8 Evaluate acceptable risk involving the use of M&S in testing.
- i) T1.9 Describe the use of M&S for risk analysis and mitigation.

11) Course assessment plan It contains an end of module exam that must be passed with a minimum of an 80% score.

12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)

1. Introduction and overview (course notes and syllabus)
2. Roles, uses, limitations and trends of models and simulations of various types; T1.1; [5]
3. Use of M&S in systems engineering and decision support for T&E; T1.2; [5]
4. Use of M&S in a system's lifecycle for all phases of test and evaluation; T1.3; [5]
5. Appropriate simulation use and model fidelity for systems validation; T1.4; [5]
6. Restrictions, applications, limitations, and risk of using M&S during T&E; T1.5; [5]
  - i) Risks of using M&S in evaluating a single system component in place of testing an entire configuration.
  - ii) In conjunction with/in place of live testing
7. Use of M&S in test planning; T1.6; [5]
8. Levels of risk in testing; T1.7 T1.8; [3]
  - a) The application of M&S in risk reduction
  - b) Acceptable risk involving the use of M&S in testing
9. Use of M&S for risk analysis and mitigation; T1.9; [5]
10. Module exam (course notes)

1) Module T1-A M&S and Live Systems (Application)

2) Coordinators

Dr. Jeffrey S. Strickland, UAH CMSA, 256-824-4415, [jeffrey.strickland@uah.edu](mailto:jeffrey.strickland@uah.edu)

Dr. Mikel D. Petty, UAH CMSA, 256-824-4368, [pettym@uah.edu](mailto:pettym@uah.edu)

3) Module description This module depicts the training required for an application knowledge level for program managers, system engineers, and T&E workforce members for ESR T1: Quantify the risk of using M&S in place of live testing. For open systems, quantify the risk of using M&S to evaluate a single system component

in place of testing an entire configuration.

- 4) ESRs that the module supports and the corresponding level of mastery  
T1 Application
- 5) Prerequisites assumed, and corresponding level of mastery TST 203, Intermediate Test and Evaluation (DAU DL Course), and Module T1-U.
- 6) Module maturity
- 7) Number of hours estimated to deliver/teach module 12 hours
- 8) Proposed delivery modality face-to-face/ Hybrid CD-ROM and Web-based format
- 9) Proposed references and texts (topics refer to these by number)
  - [1] SSTD TECHEVAL/OPEVAL LESSONS LEARNED, A Study in Test and Evaluation Management, by George Axiotis, NAVSEA T&E Office, March 16, 1998.
  - [2] TERC, GA Tech, T&E Conferences, Second Conference on the Economics of T&E, "Life Cycle Costing and Its Relationship to T&E," Mr. Waynard Devers, Institute for Defense Analyses, 1999
  - [3] Risk and Its Impact on VV&A, Recommended Practices Guide, <http://vva.dmsomil>
  - [4] RISK MANAGEMENT GUIDE FOR DOD ACQUISITION, Sixth Edition (Version 1.0), August, 2006
  - [5] Department of the Army Pamphlet 73-1: Test and Evaluation in Support of Systems Acquisition, Headquarters, Department of the Army, Washington, DC, 30 May 2003.
  - [6] Systems Analysis, Design, and Development, by Charles Wasson, NY: Wiley, 2006
- 10) Module learning objectives
  - a) T1.1 Describe the roles, uses, limitations and trends of models and simulations of various types.
  - b) T1.2 Identify how M&S is used in systems engineering and decision support for T&E.
  - c) T1.3 Identify how M&S is used in a system's lifecycle for all phases of test and evaluation.
  - d) T1.4 Identify appropriate simulation use and model fidelity for systems validation.
  - e) T1.5 Identify the restrictions, applications, limitations, and risk reduction of M&S during T&E.
  - f) T1.6 Describe the risks of using M&S to evaluate a single system component in place of testing an entire configuration.
  - g) T1.7 Describe the levels of risk in testing and how M&S can be applied in risk reduction.
  - h) T1.8 Evaluate acceptable risk involving the use of M&S in testing.



- i) T1.9 Describe the use of M&S for risk analysis and mitigation.
- 11) Course assessment plan It contains an end of module study that must be passed with a minimum of an 80% score
- 12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)
- 1. Introduction and overview (course notes and syllabus)
  - 2. Roles, uses, limitations and trends of models and simulations of various types; T1.1; [5]
  - 3. Use of M&S in systems engineering and decision support for T&E; T1.2; [5] [6]
  - 4. Use of M&S in a system's lifecycle for all phases of test and evaluation; T1.3; [5] [6]
  - 5. Appropriate simulation use and model fidelity for systems validation; T1.4; [5] [6]
  - 6. Hour six: Restrictions, applications, limitations, and risk of using M&S during T&E; T1.5; [3]
    - i) Risks of using M&S in evaluating a single system component in place of testing an entire configuration.
    - ii) In conjunction with/in place of live testing
  - 7. Use of M&S in test planning; T1.6; [5]
  - 8. Levels of risk in testing and the application of M&S in risk reduction; T1.7; [3] [4]
  - 9. Acceptable risk involving the use of M&S in testing; T1.8; [3] [4]
  - 10. Use of M&S for risk analysis and mitigation; T1.9; [5]
  - 11. Module case study (course notes)
  - 12. Module case study, continued (course notes)

- 1) Module T1-M M&S and Live Testing (Mastery)
- 2) Coordinators
  - Dr. Jeffrey S. Strickland, UAH CMSA, 256-824-4415, [jeffrey.strickland@uah.edu](mailto:jeffrey.strickland@uah.edu)
  - Dr. Mikel D. Petty, UAH CMSA, 256-824-4368, [pettym@uah.edu](mailto:pettym@uah.edu)
- 3) Module description This module depicts the training required for an mastery knowledge level for program managers, system engineers, and T&E workforce members for ESR T1: Quantify the risk of using M&S in place of live testing. For open systems, quantify the risk of using M&S to evaluate a single system component in place of testing an entire configuration.
- 4) ESRs that the module supports and the corresponding level of mastery  
T1 Mastery

- 5) Prerequisites assumed, and corresponding level of mastery TST 203, Intermediate Test and Evaluation (DAU DL Course), and Module T1-A.
- 6) Module maturity
- 7) Number of hours estimated to deliver/teach module 8 hours
- 8) Proposed delivery modality face-to-face/ Hybrid CD-ROM and Web-based format
- 9) Proposed references and texts (topics refer to these by number)
  - [1] SSTD TECHEVAL/OPEVAL LESSONS LEARNED, A Study in Test and Evaluation Management, by George Axiotis, NAVSEA T&E Office, March 16, 1998.
  - [2] TERECE, GA Tech, T&E Conferences, Second Conference on the Economics of T&E, "Life Cycle Costing and Its Relationship to T&E," Mr. Waynard Devers, Institute for Defense Analyses, 1999
  - [3] Risk and Its Impact on VV&A, Recommended Practices Guide, <http://vva.dmsa.mil>
  - [4] RISK MANAGEMENT GUIDE FOR DOD ACQUISITION, Sixth Edition (Version 1.0), August, 2006
  - [5] Department of the Army Pamphlet 73-1: Test and Evaluation in Support of Systems Acquisition, Headquarters, Department of the Army, Washington, DC, 30 May 2003.
  - [6] Systems Analysis, Design, and Development, by Charles Wasson, NY: Wiley, 2006
- 10) Module learning objectives
  - a) T1.3: Identify how M&S is used in a system's lifecycle for all phases of test and evaluation.
  - b) T1.4: Identify appropriate simulation use and model fidelity for systems validation.
  - c) T1.5: Identify the restrictions, applications, limitations, and risk reduction of M&S during T&E.
  - d) T1.6: Describe the risks of using M&S to evaluate a single system component in place of testing an entire configuration.
  - e) T1.7: Describe the levels of risk in testing and how M&S can be applied in risk reduction.
- 11) Course assessment plan It contains an end of module test that must be passed with a 100% score (may be taken as many times as necessary).
- 12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)
  - a) Introduction and overview (course notes and syllabus)
  - b) Use of M&S in a system's lifecycle for all phases of test and evaluation; T1.3; [5]
  - c) Appropriate simulation use and model fidelity for systems validation; T1.4; [5]

- d) Restrictions, applications, limitations, and risk of using M&S during T&E; T1.5; [5]
- e) Use of M&S in open systems testing; T1.6
- f) Levels of risk/and risk reduction using M&S in testing; T1.7; [3]
- g) Module case study (course notes)
- h) Module case study, continued (course notes)

**T2) Integrate M&S, live test, prototype data, historical data, component data, and scale model data into a coherent test.**

- 1) Module T2-G Integrating Data (General Awareness)
- 2) Coordinators  
 Dr. Jeffrey S. Strickland, UAH CMSA, 256-824-4415, [jeffrey.strickland@uah.edu](mailto:jeffrey.strickland@uah.edu)  
 Dr. Mikel D. Petty, UAH CMSA, 256-824-4368, [pettym@uah.edu](mailto:pettym@uah.edu)
- 3) Module description This module depicts the training required for a general awareness knowledge level for program managers, system engineers, and T&E workforce members for ESR T2: Integrate M&S, live test, prototype data, historical data, component data, and scale model data into a coherent test.
- 4) ESRs that the module supports and the corresponding level of mastery  
 T2 General Awareness
- 5) Prerequisites assumed, and corresponding level of mastery TST 102, Fundamentals of Test and Evaluation (DAU DL Course)
- 6) Module maturity:
- 7) Number of hours estimated to deliver/teach module 10 hours
- 8) Proposed delivery modality Hybrid CD-ROM and Web-based format
- 9) Proposed references and texts (topics refer to these by number)
  - [1] Guidelines on the Use of Modeling and Simulation (M&S) to Support Test and Evaluation (T&E), April 18, 2000, U.S. Army Test and Evaluation Management Agency.
  - [2] Integrating Modeling and Simulation with Test and Evaluation Activities, Major Donald Paul Waters, USAF Developmental Test and Evaluation Summit 16 - 18 November 2004, Woodland Hills, California
  - [3] M&S STUDIES IN THE CONTEXT OF T&E AND ACQUISITION: Diagnosis of the Problem: What Prior Studies Have to Say, Dr. James Coolahan, 2006
  - [4] TERC, GA Tech, Second Conference on The Economics of T&E, "Test and Evaluation of Complex Systems of Systems," Mr. Michael Teems, Applied Physics Laboratory, Johns Hopkins University, 1999
  - [5] Department of the Army Pamphlet 73-1: Test and Evaluation in Support of Systems Acquisition, Headquarters, Department of the Army, Washington, DC, 30 May 2003.
  - [6] Systems Analysis, Design, and Development, by Charles Wasson, NY: Wiley, 2006
- 10) Module learning objectives

- a) T2.1 Define the types of simulation used in T&E.
  - b) T2.2 Describe how to use the Data Source Matrix (DSM) to identify all test and simulation events and allocate MOEs/MOPs to those events.
  - c) T2.3 Identify appropriate use of M&S to plan tests, to complement system live tests, and to evaluate joint capabilities.
  - d) T2.4 Identify and define various types and levels of data arising from live and virtual testing.
  - e) T2.5 Describe how M&S can be used to develop and refine test scenarios and data matrices to obtain maximum data from limited test resources.
  - f) T2.6 Identify and describe actual examples of M&S integrated with T&E in the evaluation strategy.
  - g) T2.7 Describe and give examples of Live and M&S integration.
  - h) T2.8 Describe the Model-Test-Model methodology and list its benefits. This includes (1) the concept of using models to predict test outcomes so as to evaluate test results; (2) the concept of using test data to validate models; and (3) the concept of how M&S can be used to plan testing, to focus the testin”, and to identify problem areas. (See DA PAM 73-1)
  - i) T2.9 Identify issues and opportunities relevant to the integrated use of simulation and testing.
  - j) T2.10 Describe how results from M&S are integrated with results from other sources, such as live-fire, historical data, operational data, etc.
- 11) Course assessment plan It contains an end of module test that must be passed with a 100% score (may be taken as many times as necessary).
- 12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)
- 1. Introduction and overview (course notes and syllabus)
  - 2. Types of simulation used in T&E; T2.1; [5]
  - 3. Using the Data Source Matrix (DSM) to describe T&E events and simulation events; T2.2; [5]
  - 4. Appropriate use of M&S in T&E; T2.3; [5]
  - 5. Data arising from live and virtual testing; T2.4; [5]
  - 6. Use of M&S in developing test scenarios and data matrices; T2.5; [5]
  - 7. Examples of M&S integrated with T&E; T2.6 T2.7; [5]
  - 8. Model-Test-Model methodology; T2.8; [5]
  - 9. Issues and opportunities relevant to the integrated use of M&S in testing; T2.9; [5]
  - 10. Integrating results of M&S with results from other sources of T&E; T2.10; [5]
- 

- 1) Module T2-U Integrating Data (Understand)
- 2) Coordinators

Dr. Jeffrey S. Strickland, UAH CMSA, 256-824-4415, [jeffrey.strickland@uah.edu](mailto:jeffrey.strickland@uah.edu)  
 Dr. Mikel D. Petty, UAH CMSA, 256-824-4368, [pettym@uah.edu](mailto:pettym@uah.edu)

- 3) Module description This module depicts the training required for an understanding knowledge level for program managers, system engineers, and T&E workforce members for ESR T2: Integrate M&S, live test, prototype data, historical data, component data, and scale model data into a coherent test.
- 4) ESRs that the module supports and the corresponding level of mastery  
T2Understanding
- 5) Prerequisites assumed, and corresponding level of mastery TST 203, Intermediate Test and Evaluation (DAU DL Course), and Module T2-G.
- 6) Module maturity
- 7) Number of hours estimated to deliver/teach module 11 hours
- 8) Proposed delivery modality face-to-face/ Hybrid CD-ROM and Web-based format
- 9) Proposed references and texts (topics refer to these by number)
  - [1] Guidelines on the Use of Modeling and Simulation (M&S) to Support Test and Evaluation (T&E), April 18, 2000, U.S. Army Test and Evaluation Management Agency.
  - [2] Integrating Modeling and Simulation with Test and Evaluation Activities, Major Donald Paul Waters, USAF Developmental Test and Evaluation Summit 16 - 18 November 2004, Woodland Hills, California
  - [3] M&S STUDIES IN THE CONTEXT OF T&E AND ACQUISITION: Diagnosis of the Problem: What Prior Studies Have to Say, Dr. James Coolahan, 2006
  - [4] TERC, GA Tech, Second Conference on The Economics of T&E, "Test and Evaluation of Complex Systems of Systems," Mr. Michael Teems, Applied Physics Laboratory, Johns Hopkins University, 1999
  - [5] Department of the Army Pamphlet 73-1: Test and Evaluation in Support of Systems Acquisition, Headquarters, Department of the Army, Washington, DC, 30 May 2003.
  - [6] Systems Analysis, Design, and Development, by Charles Wasson, NY: Wiley, 2006
- 10) Module learning objectives
  - a) T2.1 Define the types of simulation used in T&E.
  - b) T2.2 Describe how to use the Data Source Matrix (DSM) to identify all test and simulation events and allocate MOEs/MOPs to those events.
  - c) T2.3 Identify appropriate use of M&S to plan tests, to complement system live tests, and to evaluate joint capabilities.
  - d) T2.4 Identify and define various types and levels of data arising from live and virtual testing.

- e) T2.5 Describe how M&S can be used to develop and refine test scenarios and data matrices to obtain maximum data from limited test resources.
  - f) T2.6 Identify and describe actual examples of M&S integrated with T&E in the evaluation strategy.
  - g) T2.7 Describe and give examples of Live and M&S integration.
  - h) T2.8 Describe the Model-Test-Model methodology and list its benefits. This includes (1) the concept of using models to predict test outcomes so as to evaluate test results; (2) the concept of using test data to validate models; and (3) the concept of how M&S can be used to plan testing, to focus the testin”, and to identify problem areas. (See DA PAM 73-1)
  - i) T2.9 Identify issues and opportunities relevant to the integrated use of simulation and testing.
  - j) T2.10 Describe how results from M&S are integrated with results from other sources, such as live-fire, historical data, operational data, etc.
- 11) Course assessment plan It contains an end of module exam that must be passed with a minimum of an 80% score.
- 12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)
- 1. Introduction and overview (course notes and syllabus)
  - 2. Types of simulation used in T&E; T2.1; [5]
  - 3. Using the Data Source Matrix (DSM) to describe T&E events and simulation events; T2.2; [5]
  - 4. Appropriate use of M&S in T&E; T2.3; [5]
  - 5. Data arising from live and virtual testing; T2.4; [5]
  - 6. Use of M&S in developing test scenarios and data matrices; T2.5 [5]
  - 7. Examples of M&S integrated with T&E; T2.6 T2.7; [5]
  - 8. Model-Test-Model methodology; T2.8; [5]
  - 9. Issues and opportunities relevant to the integrated use of M&S in testing; T2.9; [5]
  - 10. Integrating results of M&S with results from other sources of T&E; T2.10; [5]
  - 11. Module exam (course notes)
- 

- 1) Module T2-A Integrating Data (Application)
- 2) Coordinators  
Dr. Jeffrey S. Strickland, UAH CMSA, 256-824-4415, [jeffrey.strickland@uah.edu](mailto:jeffrey.strickland@uah.edu)  
Dr. Mikel D. Petty, UAH CMSA, 256-824-4368, [pettym@uah.edu](mailto:pettym@uah.edu)
- 3) Module description This module depicts the training required for an application knowledge level for program managers, system engineers, and T&E workforce

members for ESR T2: Integrate M&S, live test, prototype data, historical data, component data, and scale model data into a coherent test.

- 4) ESRs that the module supports and the corresponding level of mastery  
T2 Application
- 5) Prerequisites assumed, and corresponding level of mastery TST 203, Intermediate Test and Evaluation (DAU DL Course), and Module T2-U.
- 6) Module maturity
- 7) Number of hours estimated to deliver/teach module 12 hours
- 8) Proposed delivery modality face-to-face
- 9) Proposed references and texts (topics refer to these by number)
  - [1] Guidelines on the Use of Modeling and Simulation (M&S) to Support Test and Evaluation (T&E), April 18, 2000, U.S. Army Test and Evaluation Management Agency.
  - [2] Integrating Modeling and Simulation with Test and Evaluation Activities, Major Donald Paul Waters, USAF Developmental Test and Evaluation Summit 16 - 18 November 2004, Woodland Hills, California
  - [3] M&S STUDIES IN THE CONTEXT OF T&E AND ACQUISITION: Diagnosis of the Problem: What Prior Studies Have to Say, Dr. James Coolahan, 2006
  - [4] TERC, GA Tech, Second Conference on The Economics of T&E, "Test and Evaluation of Complex Systems of Systems," Mr. Michael Teems, Applied Physics Laboratory, Johns Hopkins University, 1999
  - [5] Department of the Army Pamphlet 73-1: Test and Evaluation in Support of Systems Acquisition, Headquarters, Department of the Army, Washington, DC, 30 May 2003.
  - [6] Systems Analysis, Design, and Development, by Charles Wasson, NY: Wiley, 2006
- 10) Module learning objectives
  - a) T2.1 Define the types of simulation used in T&E.
  - b) T2.2 Describe how to use the Data Source Matrix (DSM) to identify all test and simulation events and allocate MOEs/MOPs to those events.
  - c) T2.3 Identify appropriate use of M&S to plan tests, to complement system live tests, and to evaluate joint capabilities.
  - d) T2.4 Identify and define various types and levels of data arising from live and virtual testing.
  - e) T2.5 Describe how M&S can be used to develop and refine test scenarios and data matrices to obtain maximum data from limited test resources.
  - f) T2.6 Identify and describe actual examples of M&S integrated with T&E in the evaluation strategy.
  - g) T2.7 Describe and give examples of Live and M&S integration.



- h) T2.8 Describe the Model-Test-Model methodology and list its benefits. This includes (1) the concept of using models to predict test outcomes so as to evaluate test results; (2) the concept of using test data to validate models; and (3) the concept of how M&S can be used to plan testing, to focus the testin”, and to identify problem areas. (See DA PAM 73-1)
  - i) T2.9 Identify issues and opportunities relevant to the integrated use of simulation and testing.
  - j) T2.10 Describe how results from M&S are integrated with results from other sources, such as live-fire, historical data, operational data, etc.
- 11) Course assessment plan It contains an end of module study that must be passed with a minimum of an 80% score
- 12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)
- 1. Introduction and overview (course notes and syllabus)
  - 2. Types of simulation used in T&E; T2.1; [5]
  - 3. Using the Data Source Matrix (DSM) to describe T&E events and simulation events; T2.2; [5]
  - 4. Appropriate use of M&S in T&E; T2.3; [5]
  - 5. Data arising from live and virtual testing; T2.4; [5]
  - 6. Use of M&S in developing test scenarios and data matrices; T2.5; [5]
  - 7. Examples of M&S integrated with T&E; T2.6; [5]
  - 8. Model-Test-Model methodology; T2.8 [5]
  - 9. Issues and opportunities relevant to the integrated use of M&S in testing; T2.9; [5]
  - 10. Integrating results of M&S with results from other sources of T&E; T2.10; [5]
  - 11. Module case study (course notes)
  - 12. Module case study, continued (course notes)

1) Module T2-M Integrating Data (Mastery)

2) Coordinators

Dr. Jeffrey S. Strickland, UAH CMSA, 256-824-4415, [jeffrey.strickland@uah.edu](mailto:jeffrey.strickland@uah.edu)

Dr. Mikel D. Petty, UAH CMSA, 256-824-4368, [pettym@uah.edu](mailto:pettym@uah.edu)

3) Module description This module depicts the training required for an mastery knowledge level for program managers, system engineers, and T&E workforce members for ESR T2: Integrate M&S, live test, prototype data, historical data, component data, and scale model data into a coherent test.

4) ESRs that the module supports and the corresponding level of mastery

## T2 Mastery

- 5) Prerequisites assumed, and corresponding level of mastery TST 203, Intermediate Test and Evaluation (DAU DL Course), and Module T2-A.
- 6) Module maturity
- 7) Number of hours estimated to deliver/teach module 11 hours
- 8) Proposed delivery modality face-to-face
- 9) Proposed references and texts (topics refer to these by number)
  - [1] Guidelines on the Use of Modeling and Simulation (M&S) to Support Test and Evaluation (T&E), April 18, 2000, U.S. Army Test and Evaluation Management Agency.
  - [2] Integrating Modeling and Simulation with Test and Evaluation Activities, Major Donald Paul Waters, USAF Developmental Test and Evaluation Summit 16 - 18 November 2004, Woodland Hills, California
  - [3] M&S STUDIES IN THE CONTEXT OF T&E AND ACQUISITION: Diagnosis of the Problem: What Prior Studies Have to Say, Dr. James Coolahan, 2006
  - [4] TERC, GA Tech, Second Conference on The Economics of T&E, "Test and Evaluation of Complex Systems of Systems," Mr. Michael Teems, Applied Physics Laboratory, Johns Hopkins University, 1999
  - [5] Department of the Army Pamphlet 73-1: Test and Evaluation in Support of Systems Acquisition, Headquarters, Department of the Army, Washington, DC, 30 May 2003.
  - [6] Systems Analysis, Design, and Development, by Charles Wasson, NY: Wiley, 2006
- 10) Module learning objectives
  - a) T2.2 Describe how to use the Data Source Matrix (DSM) to identify all test and simulation events and allocate MOEs/MOPs to those events.
  - b) T2.3 Identify appropriate use of M&S to plan tests, to complement system live tests, and to evaluate joint capabilities.
  - c) T2.4 Identify and define various types and levels of data arising from live and virtual testing.
  - d) T2.5 Describe how M&S can be used to develop and refine test scenarios and data matrices to obtain maximum data from limited test resources.
  - e) T2.6 Identify and describe actual examples of M&S integrated with T&E in the evaluation strategy.
  - f) T2.8 Describe the Model-Test-Model methodology and list its benefits. This includes (1) the concept of using models to predict test outcomes so as to evaluate test results; (2) the concept of using test data to validate models; and (3) the concept of how M&S can be used to plan testing, to focus the testin", and to identify problem areas. (See DA PAM 73-1)

- g) T2.9 Identify issues and opportunities relevant to the integrated use of simulation and testing.
  - h) T2.10 Describe how results from M&S are integrated with results from other sources, such as live-fire, historical data, operational data, etc.
- 11) Course assessment plan It contains an end of module test that must be passed with a 100% score (may be taken as many times as necessary).
- 12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)
- 1. Introduction and overview (course notes and syllabus)
  - 2. Using the Data Source Matrix (DSM) to describe T&E events and simulation events; T2.2; [5]
  - 3. Appropriate use of M&S in T&E; T2.3[5]
  - 4. Data arising from live and virtual testing; T2.4; [5]
  - 5. Use of M&S in developing test scenarios and data matrices; T2.5; [5]
  - 6. Examples of M&S integrated with T&E; T2.6 T2.7; [5]
  - 7. Model-Test-Model methodology; T2.8; [5]
  - 8. Issues and opportunities relevant to the integrated use of M&S in testing; T2.9; [5]
  - 9. Integrating results of M&S with results from other sources of T&E; T2.10; [5]
  - 10. Module case study (course notes)
  - 11. Module case study, continued (course notes)

**T3) Describe the different types of testing (i.e. unit, integration, developmental, interoperability, operational, and live fire testing) and identify the utility, limitations and risks for use of M&S in each. Understand the critical interrelationships and balance between modeling and simulation and more traditional forms of test and evaluation (T&E).**

1) Module T3-G Testing and M&S (General Awareness)

2) Coordinators

Dr. Jeffrey S. Strickland, UAH CMSA, 256-824-4415, [jeffrey.strickland@uah.edu](mailto:jeffrey.strickland@uah.edu)

Dr. Mikel D. Petty, UAH CMSA, 256-824-4368, [pettym@uah.edu](mailto:pettym@uah.edu)

3) Module description This module depicts the training required for a general awareness knowledge level for program managers, system engineers, and T&E workforce members for ESR T3: Describe the different types of testing (i.e. unit, integration, developmental, interoperability, operational, and live fire testing) and identify the utility, limitations, and risks for use of M&S in each. Understand the critical interrelationships and balance between modeling and simulation and more traditional forms of test and evaluation (T&E).

4) ESRs that the module supports and the corresponding level of mastery  
T3 General Awareness

5) Prerequisites assumed, and corresponding level of mastery TST 102, Fundamentals of Test and Evaluation (DAU DL Course)

6) Module maturity

7) Number of hours estimated to deliver/teach module 10 hours

8) Proposed delivery modality Hybrid CD-ROM and Web-based format

9) Proposed references and texts (topics refer to these by number)

[1] Improved Operational Testing and Evaluation: Better Measurement and Test Design for the Interim Brigade Combat Team with Stryker Vehicles, Phase I Report (2003), National Academies Press

[2] Testing of Defense Systems in an Evolutionary Acquisition Environment (2006), National Academies Press

[3] Guidelines on the Use of Modeling and Simulation (M&S) to Support Test and Evaluation (T&E), April 18, 2000, U.S. Army Test and Evaluation Management Agency

[4] Systems Analysis, Design, and Development, by Charles Wasson, NY: Wiley, 2006

[5] DoD Directive 5000.59, COMOPTEVFORINST 5000.1

[6] Department of the Army Pamphlet 73-1: Test and Evaluation in Support of Systems Acquisition, Headquarters, Department of the Army, Washington, DC, 30 May 2003.

#### Module learning objectives

- a) T3.1 Describe the evolutionary test process within the SE process and how M&S supports it.
  - b) T3.2 Identify the components and structure of integration testing and the place for M&S in this structure.
  - c) T3.3 Describe and provide examples of developmental testing (DT) and identify the utility, limitations, and risks for use of M&S in DT.
  - d) T3.4 Describe and provide examples of types of operational testing (OT) identify the utility, limitations, and risks for use of M&S in OT.
  - e) T3.5 Describe and provide examples of unit testing identify the utility, limitations, and risks for use of M&S in unit testing
  - f) T3.6 Describe and provide examples of M&S in support of live fire testing, and identify the utility, limitations, and risks for use of M&S in live fire testing.
  - g) T3.7 Describe and provide examples of interoperability testing and identify the utility, limitations, and risks for use of M&S in interoperability testing.
  - h) T3.8 Describe the critical interrelationships and balance between modeling and simulation and more traditional forms of test and evaluation (T&E).
  - i) T3.9 Describe test procedures for M&S-base Testing in each type (DT, OT, IT, etc) and sub-type (LUT, IOT, FOT, etc.) of testing.
- 10) Course assessment plan It contains an end of module test that must be passed with a 100% score (may be taken as many times as necessary).
- 11) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)
1. Introduction and overview (course notes and syllabus)
  2. Use of M&S in evolutionary test process; T3.1; [6] [2]
  3. Role of M&S in integration testing; T3.2; [6]
  4. Role of M&S in developmental testing; T3.3; [6]
  5. Role of M&S in operational testing; T3.4; [6]
  6. Role of M&S in unit testing; T3.5; [6]
  7. Role of M&S in interoperability testing; T3.7; [6]
  8. Role of M&S in live fire testing; T3.6; [6]
  9. Interrelationships between M&S and traditional forms of T&E; T3.8; [6] [4]
  10. Test procedures for various types of testing; T3.9; [6]

- 
- 1) Module T3-U Testing and M&S (Understand)
  - 2) Coordinators

Dr. Jeffrey S. Strickland, UAH CMSA, 256-824-4415, [jeffrey.strickland@uah.edu](mailto:jeffrey.strickland@uah.edu)  
 Dr. Mikel D. Petty, UAH CMSA, 256-824-4368, [pettym@uah.edu](mailto:pettym@uah.edu)

- 3) Module description This module depicts the training required for a general awareness knowledge level for program managers, system engineers, and T&E workforce members for ESR T3: Describe the different types of testing (i.e. unit, integration, developmental, interoperability, operational, and live fire testing) and identify the utility, limitations, and risks for use of M&S in each. Understand the critical interrelationships and balance between modeling and simulation and more traditional forms of test and evaluation (T&E).
- 4) ESRs that the module supports and the corresponding level of mastery  
T3 Understanding
- 5) Prerequisites assumed, and corresponding level of mastery TST 102, Fundamentals of Test and Evaluation (DAU DL Course), and T3-G
- 6) Module maturity
- 7) Number of hours estimated to deliver/teach module 11 hours
- 8) Proposed delivery modality face-to-face/Hybrid CD-ROM and Web-based format
- 9) Proposed references and texts (topics refer to these by number)
  - [1] Improved Operational Testing and Evaluation: Better Measurement and Test Design for the Interim Brigade Combat Team with Stryker Vehicles, Phase I Report (2003), National Academies Press
  - [2] Testing of Defense Systems in an Evolutionary Acquisition Environment (2006), National Academies Press
  - [3] Guidelines on the Use of Modeling and Simulation (M&S) to Support Test and Evaluation (T&E), April 18, 2000, U.S. Army Test and Evaluation Management Agency
  - [4] Systems Analysis, Design, and Development, by Charles Wasson, NY: Wiley, 2006
  - [5] DoD Directive 5000.59, COMOPTEVFORINST 5000.1
  - [6] Department of the Army Pamphlet 73-1: Test and Evaluation in Support of Systems Acquisition, Headquarters, Department of the Army, Washington, DC, 30 May 2003.
- 10) Module learning objectives
  - a) T3.1 Describe the evolutionary test process within the SE process and how M&S supports it.
  - b) T3.2 Identify the components and structure of integration testing and the place for M&S in this structure.
  - c) T3.3 Describe and provide examples of developmental testing (DT) and identify the utility, limitations, and risks for use of M&S in DT.

- d) T3.4 Describe and provide examples of types of operational testing (OT) identify the utility, limitations, and risks for use of M&S in OT.
  - e) T3.5 Describe and provide examples of unit testing identify the utility, limitations, and risks for use of M&S in unit testing
  - f) T3.6 Describe and provide examples of M&S in support of live fire testing, and identify the utility, limitations, and risks for use of M&S in live fire testing.
  - g) T3.7 Describe and provide examples of interoperability testing and identify the utility, limitations, and risks for use of M&S in interoperability testing.
  - h) T3.8 Describe the critical interrelationships and balance between modeling and simulation and more traditional forms of test and evaluation (T&E).
  - i) T3.9 Describe test procedures for M&S-base Testing in each type (DT, OT, IT, etc) and sub-type (LUT, IOT, FOT, etc.) of testing.
- 11) Course assessment plan It contains an end of module test that must be passed with a minimum of an 80% score.
- 12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)
- 1. Introduction and overview (course notes and syllabus)
  - 2. Use of M&S in evolutionary test process; T3.1; [6] [2]
  - 3. Role of M&S in integration testing; T3.2; [6]
  - 4. Role of M&S in developmental testing; T3.3; [6]
  - 5. Role of M&S in operational testing; T3.4; [6]
  - 6. Role of M&S in unit testing; T3.5; [6]
  - 7. Role of M&S in interoperability testing; T3.7; [6]
  - 8. Role of M&S in live fire testing; T3.6; [6]
  - 9. Interrelationships between M&S and traditional forms of T&E; T3.8; [6] [4]
  - 10. Test procedures for various types of testing; T3.9; [6]
  - 11. Module exam (course notes)

1) Module T3-A Testing and M&S (Application)

2) Coordinators

Dr. Jeffrey S. Strickland, UAH CMSA, 256-824-4415, [jeffrey.strickland@uah.edu](mailto:jeffrey.strickland@uah.edu)

Dr. Mikel D. Petty, UAH CMSA, 256-824-4368, [pettym@uah.edu](mailto:pettym@uah.edu)

- 3) Module description This module depicts the training required for a general awareness knowledge level for program managers, system engineers, and T&E workforce members for ESR T3: Describe the different types of testing (i.e. unit, integration, developmental, interoperability, operational, and live fire testing) and identify the utility, limitations, and risks for use of M&S in each. Understand the critical interrelationships and balance between modeling and simulation and more traditional forms of test and evaluation (T&E).

- 4) ESRs that the module supports and the corresponding level of mastery  
T3Application
- 5) Prerequisites assumed, and corresponding level of mastery TST 102, Fundamentals of Test and Evaluation (DAU DL Course), and T3-U
- 6) Module maturity
- 7) Number of hours estimated to deliver/teach module 12 hours
- 8) Proposed delivery modality face-to-face
- 9) Proposed references and texts (topics refer to these by number)
  - [1] Improved Operational Testing and Evaluation: Better Measurement and Test Design for the Interim Brigade Combat Team with Stryker Vehicles, Phase I Report (2003), National Academies Press
  - [2] Testing of Defense Systems in an Evolutionary Acquisition Environment (2006), National Academies Press
  - [3] Guidelines on the Use of Modeling and Simulation (M&S) to Support Test and Evaluation (T&E), April 18, 2000, U.S. Army Test and Evaluation Management Agency
  - [4] Systems Analysis, Design, and Development, by Charles Wasson, NY: Wiley, 2006
  - [5] DoD Directive 5000.59, COMOPTEVFORINST 5000.1
  - [6] Department of the Army Pamphlet 73-1: Test and Evaluation in Support of Systems Acquisition, Headquarters, Department of the Army, Washington, DC, 30 May 2003.
- 10) Module learning objectives
  - a) T3.1 Describe the evolutionary test process within the SE process and how M&S supports it.
  - b) T3.2 Identify the components and structure of integration testing and the place for M&S in this structure.
  - c) T3.3 Describe and provide examples of developmental testing (DT) and identify the utility, limitations, and risks for use of M&S in DT.
  - d) T3.4 Describe and provide examples of types of operational testing (OT) identify the utility, limitations, and risks for use of M&S in OT.
  - e) T3.5 Describe and provide examples of unit testing identify the utility, limitations, and risks for use of M&S in unit testing
  - f) T3.6 Describe and provide examples of M&S in support of live fire testing, and identify the utility, limitations, and risks for use of M&S in live fire testing.
  - g) T3.7 Describe and provide examples of interoperability testing and identify the utility, limitations, and risks for use of M&S in interoperability testing.
  - h) T3.8 Describe the critical interrelationships and balance between modeling and simulation and more traditional forms of test and evaluation (T&E).



- i) T3.9 Describe test procedures for M&S-base Testing in each type (DT, OT, IT, etc) and sub-type (LUT, IOT, FOT, etc.) of testing.
  - 11) Course assessment plan It contains an end of module test that must be passed with a minimum of an 80% score.
  - 12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)
    - 1. Introduction and overview (course notes and syllabus)
    - 2. Use of M&S in evolutionary test process; T3.1; [6] [2]
    - 3. Role of M&S in integration testing; T3.2; [6]
    - 4. Role of M&S in developmental testing; T3.3; [6]
    - 5. Role of M&S in operational testing; T3.4; [6]
    - 6. Role of M&S in unit testing; T3.5; [6]
    - 7. Role of M&S in interoperability testing; T3.7; [6]
    - 8. Role of M&S in live fire testing; T3. 6; [6]
    - 9. Interrelationships between M&S and traditional forms of T&E; T3.8; [6] [4]
    - 10. Test procedures for various types of testing; T3.9; [6]
    - 11. Module case study (course notes)
    - 12. Module case study, continued (course notes)
- 

- 1) Module T3-M Testing and M&S (Mastery)
- 2) Coordinators  
 Dr. Jeffrey S. Strickland, UAH CMSA, 256-824-4415, [jeffrey.strickland@uah.edu](mailto:jeffrey.strickland@uah.edu)  
 Dr. Mikel D. Petty, UAH CMSA, 256-824-4368, [pettym@uah.edu](mailto:pettym@uah.edu)
- 3) Module description This module depicts the training required for a general awareness knowledge level for program managers, system engineers, and T&E workforce members for ESR T3: Describe the different types of testing (i.e. unit, integration, developmental, interoperability, operational, and live fire testing) and identify the utility, limitations, and risks for use of M&S in each. Understand the critical interrelationships and balance between modeling and simulation and more traditional forms of test and evaluation (T&E).
- 4) ESRs that the module supports and the corresponding level of mastery  
 T3 Mastery
- 5) Prerequisites assumed, and corresponding level of mastery TST 102, Fundamentals of Test and Evaluation (DAU DL Course), and T3-A
- 6) Module maturity

- 7) Number of hours estimated to deliver/teach module 12 hours
- 8) Proposed delivery modality face-to-face
- 9) Proposed references and texts (topics refer to these by number)
  - [1] Improved Operational Testing and Evaluation: Better Measurement and Test Design for the Interim Brigade Combat Team with Stryker Vehicles, Phase I Report (2003), National Academies Press
  - [2] Testing of Defense Systems in an Evolutionary Acquisition Environment (2006), National Academies Press
  - [3] Guidelines on the Use of Modeling and Simulation (M&S) to Support Test and Evaluation (T&E), April 18, 2000, U.S. Army Test and Evaluation Management Agency
  - [4] Systems Analysis, Design, and Development, by Charles Wasson, NY: Wiley, 2006
  - [5] DoD Directive 5000.59, COMOPTEVFORINST 5000.1
  - [6] Department of the Army Pamphlet 73-1: Test and Evaluation in Support of Systems Acquisition, Headquarters, Department of the Army, Washington, DC, 30 May 2003.
- 10) Module learning objectives
  - a) T3.1 Describe the evolutionary test process within the SE process and how M&S supports it.
  - b) T3.2 Identify the components and structure of integration testing and the place for M&S in this structure.
  - c) T3.3 Describe and provide examples of developmental testing (DT) and identify the utility, limitations, and risks for use of M&S in DT.
  - d) T3.4 Describe and provide examples of types of operational testing (OT) identify the utility, limitations, and risks for use of M&S in OT.
  - e) T3.5 Describe and provide examples of unit testing identify the utility, limitations, and risks for use of M&S in unit testing
  - f) T3.6 Describe and provide examples of M&S in support of live fire testing, and identify the utility, limitations, and risks for use of M&S in live fire testing.
  - g) T3.7 Describe and provide examples of interoperability testing and identify the utility, limitations, and risks for use of M&S in interoperability testing.
  - h) T3.8 Describe the critical interrelationships and balance between modeling and simulation and more traditional forms of test and evaluation (T&E).
  - i) T3.9 Describe test procedures for M&S-base testing in each type (DT, OT, IT, etc) and sub-type (LUT, IOT, FOT, etc.) of testing.
- 11) Course assessment plan It contains an end of module test that must be passed with a minimum of an 80% score.
- 12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)

1. Introduction and overview (course notes and syllabus)
2. Use of M&S in evolutionary test process; T3.1; [6] [2]
3. Role of M&S in integration testing; T3.2; [6]
4. Role of M&S in developmental testing; T3.3; [6]
5. Role of M&S in operational testing; T3.4; [6]
6. Role of M&S in unit testing; T3.5; [6]
7. Role of M&S in interoperability testing; T3.7; [6]
8. Role of M&S in live fire testing; T3.6; [6]
9. Interrelationships between M&S and traditional forms of T&E; T3.8 [6]  
[4]
10. Test procedures for various types of testing; T3.9; [6]
11. Module case study (course notes)
12. Module case study, continued (course notes)

- 
- 1) Title: M&S and Test and Evaluation
  - 2) Module coordinator / point of contact and contact information  
Jim Campbell, GMU, [jcampbell@alionscience.com](mailto:jcampbell@alionscience.com), 703-933-3356
  - 3) Module description (short description) at the completion of this module, students will be able to identify M&S applications that support T&E and apply M&S concepts to T&E plans for supplementing live test.
  - 4) ESR supported: T3 Describe the different types of testing (i.e. unit, integration, developmental, interoperability, operational, and live fire testing) and identify the utility, limitations and risks for use of M&S in each. Understand the critical interrelationships and balance between modeling and simulation and more traditional forms of test and evaluation (T&E).
  - 5) Prerequisites ACQ 101, ACQ 201, ESR P10.
  - 6) Module maturity: This material has been taught in the GMU CPE course and in the MSSOC and T&E Workshop from MSIAC the GMU course is at the understanding level and the MSIAC courses are at the general awareness level.
  - 7) Number of hours: Four.
  - 8) Proposed Delivery: face-to-face, or VTC; resident, or customer's site
  - 9) Proposed references and texts
    - r) DoD Directive 5000.1, Defense Acquisition System, 12 May 2003

- s) DoD Instruction 5000.2, Operation of the Defense Acquisition System, 12 May 2003
  - t) DoD Directive 5000.59, DoD Modeling and Simulation (M&S) Management, 8 August 2007
  - u) Defense Acquisition Guidebook, Version 1.0, 17 October 2004
  - v) AR 73-1, Test and Evaluation Policy, 1 August 2006
  - w) SECNAVINST 5000.2C, Implementation and Operation of the Defense Acquisition System and the Joint Capabilities Integration and Development System, 19 November 2004
  - x) AFI 99-103, Capabilities Based Test and Evaluation, 6 August 2004
- 10) Module learning objectives:
- T3.1: List the three types of T&E
  - T3.2: Describe M&S requirements in T&E as listed in DoD 5000.2
  - T3.3: Describe the philosophy of M&S in testing
  - T3.4: Describe how M&S supplements live testing
  - T3.5: List the T&E requirement documents for the student's Service
- 11) Course assessment plan: Examination and practical exercise.
- 12) Topic list by hour of instruction and reference:
- i) Hour one: Introduction and overview (course notes and syllabus) T3.1, T3.2
  - ii) Hour two: M&S applications in T&E (course notes and syllabus) T3.3, T3.4, T3.5
  - iii) Hour three: Practical application (course notes and syllabus) T3 all
  - iv) Hour four: Examination and summary (course notes and syllabus) T3 all
- 13) Additional Requirements: N/A

**T4) Identify strategies for M&S use in the test planning and execution process.**

- 1) Module T4-G Test Planning and Execution (General Awareness)
- 2) Coordinators  
 Dr. Jeffrey S. Strickland, UAH CMSA, 256-824-4415, [jeffrey.strickland@uah.edu](mailto:jeffrey.strickland@uah.edu)  
 Dr. Mikel D. Petty, UAH CMSA, 256-824-4368, [pettym@uah.edu](mailto:pettym@uah.edu)
- 3) Module description This module depicts the training required for a general awareness knowledge level for program managers, system engineers, and T&E workforce members for ESR T4: Identify strategies for M&S use in the test planning and execution process.
- 4) ESRs that the module supports and the corresponding level of mastery  
 T3 General Awareness
- 5) Prerequisites assumed, and corresponding level of mastery TST 102, Fundamentals of Test and Evaluation (DAU DL Course)
- 6) Module maturity
- 7) Number of hours estimated to deliver/teach module 7 hours
- 8) Proposed delivery modality Hybrid CD-ROM and Web-based format
- 9) Proposed references and texts (topics refer to these by number)  
 [1] Interweaving Test and Evaluation throughout the Systems Engineering Process, Josh Tribble, 2005  
 [2] Statistics, Testing, and Defense Acquisition: (1998), Commission on Behavioral and Social Sciences and Education (CBASSE), NAP  
 [3] Guidelines on the Use of Modeling and Simulation (M&S) to Support Test and Evaluation (T&E), April 18, 2000, U.S. Army Test and Evaluation Management Agency  
 [4] Systems Analysis, Design, and Development, by Charles Wasson, NY: Wiley, 2006  
 [5] DoDI 5000.2, Appendix B, Enclosure 5.  
 [6] Department of the Army Pamphlet 73-1: Test and Evaluation in Support of Systems Acquisition, Headquarters, Department of the Army, Washington, DC, 30 May 2003.
- 10) Module learning objectives
  - a) T4.1 Describe the elements, including the use of M&S, of a Test and Evaluation Master Plan (TEMP).
  - b) T4.2 Describe relationship and purposes of the TEMP, System Evaluation Plan (SEP), and test/simulation execution strategy (T/SES)

- c) T4.3 Describe the personnel, scope, approach, resources, and schedule for M&S of intended testing activities.
  - d) T4.4 Describe the forms of use of simulation in support of test planning, test execution, and systems analysis.
  - e) T4.5 Identify M&S strategies to optimize the use of scarce resources in executing test and evaluation programs.
  - f) T4.6 Describe how to use M&S to enable better test planning for operational live tests.
  - g) T4.7 Describe the life-cycle costs and its relationship to M&S in the context of T&E.
- 11) Course assessment plan It contains an end of module test that must be passed with a 100% score (may be taken as many times as necessary).
- 12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)
- 1. Introduction and overview (course notes and syllabus)
  - 2. M&S and the Test and Evaluation Master Plan (TEMP); T4.1; [6]
  - 3. M&S and the System Evaluation Plan (SEP); T4.2; [6]
  - 4. The Test/Simulation Execution Strategy (T/SES); T4.3; [6]
  - 5. Programmatic for M&S in T&E; T4.4; [6]
  - 6. M&S in test planning, test execution, and systems analysis; T4.5 T4.6[6]
  - 7. M&S life-cycle costs in T&E; T4.7; [6]

- 1) Module T4-U Test Planning and Execution (Understand)
- 2) Coordinators  
Dr. Jeffrey S. Strickland, UAH CMSA, 256-824-4415, [jeffrey.strickland@uah.edu](mailto:jeffrey.strickland@uah.edu)  
Dr. Mikel D. Petty, UAH CMSA, 256-824-4368, [pettym@uah.edu](mailto:pettym@uah.edu)
- 3) Module description This module depicts the training required for a understanding knowledge level for program managers, system engineers, and T&E workforce members for ESR T4: Identify strategies for M&S use in the test planning and execution process.
- 4) ESRs that the module supports and the corresponding level of mastery  
T3 Understanding
- 5) Prerequisites assumed, and corresponding level of mastery TST 102, Fundamentals of Test and Evaluation (DAU DL Course), Module T4-G.
- 6) Module maturity:

- 7) Number of hours estimated to deliver/teach module 8 hours
- 8) Proposed delivery modality face-to-face/Hybrid CD-ROM and Web-based format
- 9) Proposed references and texts (topics refer to these by number)
  - [1] Interweaving Test and Evaluation throughout the Systems Engineering Process, Josh Tribble, 2005
  - [2] Statistics, Testing, and Defense Acquisition: (1998), Commission on Behavioral and Social Sciences and Education (CBASSE), NAP
  - [3] Guidelines on the Use of Modeling and Simulation (M&S) to Support Test and Evaluation (T&E), April 18, 2000, U.S. Army Test and Evaluation Management Agency
  - [4] Systems Analysis, Design, and Development, by Charles Wasson, NY: Wiley, 2006
  - [5] DoDI 5000.2, Appendix B, Enclosure 5.
  - [6] Department of the Army Pamphlet 73-1: Test and Evaluation in Support of Systems Acquisition, Headquarters, Department of the Army, Washington, DC, 30 May 2003.
- 10) Module learning objectives
  - a) T4.1 Describe the elements, including the use of M&S, of a Test and Evaluation Master Plan (TEMP).
  - b) T4.2 Describe relationship and purposes of the TEMP, System Evaluation Plan (SEP), and test/simulation execution strategy (T/SES)
  - c) T4.3 Describe the personnel, scope, approach, resources, and schedule for M&S of intended testing activities.
  - d) T4.4 Describe the forms of use of simulation in support of test planning, test execution, and systems analysis.
  - e) T4.5 Identify M&S strategies to optimize the use of scarce resources in executing test and evaluation programs.
  - f) T4.6 Describe how to use M&S to enable better test planning for operational live tests.
  - g) T4.7 Describe the life-cycle costs and its relationship to M&S in the context of T&E.
- 11) Course assessment plan It contains an end of module test that must be passed with a minimum of an 80% score.
- 12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)
  1. Introduction and overview (course notes and syllabus)
  2. M&S and the Test and Evaluation Master Plan (TEMP); T4.1; [6]
  3. M&S and the System Evaluation Plan (SEP); T4.2; [6]
  4. The Test/Simulation Execution Strategy (T/SES); T4.2; [6]
  5. Programmatic for M&S in T&E; T4.3; [6]

6. M&S in test planning, test execution, and systems analysis; T4.4 T4.5 T4.6; [6]
7. M&S life-cycle costs in T&E; T4.7; [6]
8. Module exam (course notes)

- 
- 1) Module T4-A Test Planning and Execution (Application)
  - 2) Coordinators  
Dr. Jeffrey S. Strickland, UAH CMSA, 256-824-4415, [jeffrey.strickland@uah.edu](mailto:jeffrey.strickland@uah.edu)  
Dr. Mikel D. Petty, UAH CMSA, 256-824-4368, [pettym@uah.edu](mailto:pettym@uah.edu)
  - 3) Module description This module depicts the training required for an application knowledge level for program managers, system engineers, and T&E workforce members for ESR T4: Identify strategies for M&S use in the test planning and execution process.
  - 4) ESRs that the module supports and the corresponding level of mastery  
T3 Application
  - 5) Prerequisites assumed, and corresponding level of mastery TST 102, Fundamentals of Test and Evaluation (DAU DL Course), Module T4-U.
  - 6) Module maturity
  - 7) Number of hours estimated to deliver/teach module 9 hours
  - 8) Proposed delivery modality face-to-face
  - 9) Proposed references and texts (topics refer to these by number)  
[1] Interweaving Test and Evaluation throughout the Systems Engineering Process, Josh Tribble, 2005  
[2] Statistics, Testing, and Defense Acquisition: (1998), Commission on Behavioral and Social Sciences and Education (CBASSE), NAP  
[3] Guidelines on the Use of Modeling and Simulation (M&S) to Support Test and Evaluation (T&E), April 18, 2000, U.S. Army Test and Evaluation Management Agency  
[4] Systems Analysis, Design, and Development, by Charles Wasson, NY: Wiley, 2006  
[5] DoDI 5000.2, Appendix B, Enclosure 5.  
[6] Department of the Army Pamphlet 73-1: Test and Evaluation in Support of Systems Acquisition, Headquarters, Department of the Army, Washington, DC, 30 May 2003.
  - 10) Module learning objectives



- a) T4.1 Describe the elements, including the use of M&S, of a Test and Evaluation Master Plan (TEMP).
  - b) T4.2 Describe relationship and purposes of the TEMP, System Evaluation Plan (SEP), and test/simulation execution strategy (T/SES)
  - c) T4.3 Describe the personnel, scope, approach, resources, and schedule for M&S of intended testing activities.
  - d) T4.4 Describe the forms of use of simulation in support of test planning, test execution, and systems analysis.
  - e) T4.5 Identify M&S strategies to optimize the use of scarce resources in executing test and evaluation programs.
  - f) T4.6 Describe how to use M&S to enable better test planning for operational live tests.
  - g) T4.7 Describe the life-cycle costs and its relationship to M&S in the context of T&E.
- 11) Course assessment plan It contains an end of module case study that must be passed with a minimum of an 80% score.
- 12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)
- 1. Introduction and overview (course notes and syllabus)
    - 2. M&S and the Test and Evaluation Master Plan (TEMP); T4.1; [6]
  - 3. M&S and the System Evaluation Plan (SEP); T4.2; [6]
    - 4. The Test/Simulation Execution Strategy (T/SES); T4.2; [6]
  - 5. Programmatic for M&S in T&E; T4.3; [6]
    - 6. M&S in test planning, test execution, and systems analysis; T4.4 T4.5 T4.6[6]
  - 7. M&S life-cycle costs in T&E; T4.7; [6]
  - 8. Module case study (course notes)
    - 9. Hour Eight Continued (course notes)

- 1) Module T4-M Test Planning and Execution (Mastery)
- 2) Coordinators  
 Dr. Jeffrey S. Strickland, UAH CMSA, 256-824-4415, [jeffrey.strickland@uah.edu](mailto:jeffrey.strickland@uah.edu)  
 Dr. Mikel D. Petty, UAH CMSA, 256-824-4368, [pettym@uah.edu](mailto:pettym@uah.edu)
- 3) Module description This module depicts the training required for a mastery knowledge level for program managers, system engineers, and T&E workforce members for ESR T4: Identify strategies for M&S use in the test planning and execution process.
- 4) ESRs that the module supports and the corresponding level of mastery

### T3 Mastery

- 5) Prerequisites assumed, and corresponding level of mastery TST 102, Fundamentals of Test and Evaluation (DAU DL Course), Module T4-A.
- 6) Module maturity
- 7) Number of hours estimated to deliver/teach module 9 hours
- 8) Proposed delivery modality face-to-face
- 9) Proposed references and texts (topics refer to these by number)
  - [1] Interweaving Test and Evaluation throughout the Systems Engineering Process, Josh Tribble, 2005
  - [2] Statistics, Testing, and Defense Acquisition: (1998), Commission on Behavioral and Social Sciences and Education (CBASSE), NAP
  - [3] Guidelines on the Use of Modeling and Simulation (M&S) to Support Test and Evaluation (T&E), April 18, 2000, U.S. Army Test and Evaluation Management Agency
  - [4] Systems Analysis, Design, and Development, by Charles Wasson, NY: Wiley, 2006
  - [5] DoDI 5000.2, Appendix B, Enclosure 5.
  - [6] Department of the Army Pamphlet 73-1: Test and Evaluation in Support of Systems Acquisition, Headquarters, Department of the Army, Washington, DC, 30 May 2003.
- 10) Module learning objectives
  - a) T4.1 Describe the elements, including the use of M&S, of a Test and Evaluation Master Plan (TEMP).
  - b) T4.2 Describe relationship and purposes of the TEMP, System Evaluation Plan (SEP), and test/simulation execution strategy (T/SES)
  - c) T4.3 Describe the personnel, scope, approach, resources, and schedule for M&S of intended testing activities.
  - d) T4.4 Describe the forms of use of simulation in support of test planning, test execution, and systems analysis.
  - e) T4.5 Identify M&S strategies to optimize the use of scarce resources in executing test and evaluation programs.
  - f) T4.6 Describe how to use M&S to enable better test planning for operational live tests.
  - g) T4.7 Describe the life-cycle costs and its relationship to M&S in the context of T&E.
- 11) Course assessment plan It contains an end of module case study that must be passed with a minimum of an 80% score.

12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)

1. Introduction and overview (course notes and syllabus)
  2. M&S and the Test and Evaluation Master Plan (TEMP); T4.1; [6]
3. M&S and the System Evaluation Plan (SEP); T4.2; [6]
  4. The Test/Simulation Execution Strategy (T/SES); T4.2; [6]
5. Programmatic for M&S in T&E; T4.3; [6]
  6. M&S in test planning, test execution, and systems analysis; T4.4 T4.5 T4.6; [6]
7. M&S life-cycle costs in T&E; T4.7; [6]
8. Module case study (course notes)
  9. Hour Eight Continued (course notes)

**T5) Match existing M&S T&E facilities used within the DoD to a given program need, as appropriate.**

- 1) Module T5-G M&S T&E Facilities (General Awareness)
- 2) Coordinators  
 Dr. Jeff Little, UAH CMSA, 256-824-2351, [jkl0001@uah.edu](mailto:jkl0001@uah.edu)  
 Dr. Mikel Petty, UAH CMSA, 256-824-4368, [pettym@uah.edu](mailto:pettym@uah.edu)
- 3) Module description This module depicts the training required for program managers, systems engineers, and T&E workforce members to have a general awareness of the existing M&S T&E facilities used within the DoD and their role in acquisition.
- 4) ESRs that the module supports and the corresponding level of mastery  
 T5 General Awareness
- 5) Prerequisites assumed, and corresponding level of mastery None.
- 6) Module maturity Assorted briefings and short courses have been presented at MSRC's since the inception of the HPC Modernization Program (HPCMP) in 1992. Therefore there is a wealth of information and course material available via HPCMP internet sites and offices.
- 7) Number of hours estimated to deliver/teach module 2 hours
- 8) Proposed delivery modality face-to-face, online
- 9) Proposed references and texts (topics refer to these by number)  
 [1] DoD High Performance Computing Modernization Program:  
<http://www.hpcmo.hpc.mil/>  
 [2] Army Research Laboratory (ARL) MSRC: <http://www.arl.hpc.mil/>  
 [3] Aeronautical Systems Center (ASC) MSRC: <http://www.asc.hpc.mil/>  
 [4] Engineer Research and Development Center (ERDC) MSRC:  
<http://www.erdhpc.mil/>  
 [5] Naval Oceanographic Office (NAVO) MSRC: <http://www.navo.hpc.mil/>
- 10) Module learning objectives
  - a) T5.1 List the key facilities which support DoD M&S T&E (Major Shared Resource Centers).
  - b) T5.2 Describe the missions of the key facilities which support DoD M&S T&E.
  - c) T5.3 List and link the principle DoD customers to the key facilities which support DoD M&S T&E.
  - d) T5.4 Update and list current capabilities (strengths and weaknesses) of the key facilities which support DoD M&S T&E.

- e) T5.5 Predict improvement and modernization activities of the key facilities which support DoD M&S T&E.
- f) T5.6 Describe emerging facilities (currently under development) which will support DoD M&S T&E.

11) Course assessment plan In-class questions and immediate responses.

12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)

- 1. Introduction and Overview of DoD High Performance Computing (HPC)—Describe the origin, history and current organization of the HPC Management Office (HPCMO); T5.1-T5.3; [1]
- 2. Major Shared Resource Center Overviews—Unique and Joint Capabilities; T5.4-T5.6; [1] [2] [3] [4] [5]

1) Module T5-U M&S T&E Facilities (Understand)

2) Coordinators

Dr. Jeff Little, UAH CMSA, 256-824-2351, [jk10001@uah.edu](mailto:jk10001@uah.edu)

Dr. Mikel Petty, UAH CMSA, 256-824-4368, [pettym@uah.edu](mailto:pettym@uah.edu)

3) Module description This module depicts the training required for program managers, systems engineers, and T&E workforce members to have an understanding of the existing M&S T&E facilities used within the DoD and their role in acquisition.

4) ESRs that the module supports and the corresponding level of mastery  
T5 Understanding

5) Prerequisites assumed, and corresponding level of mastery None.

6) Module maturity Assorted briefings and short courses have been presented at MSRC's since the inception of the HPC Modernization Program (HPCMP) in 1992. Therefore there is a wealth of information and course material available via HPCMP internet sites and offices.

7) Number of hours estimated to deliver/teach module 2 hours

8) Proposed delivery face-to-face, online

9) Proposed references and texts (topics refer to these by number)

[1] DoD High Performance Computing Modernization Program:

<http://www.hpcmo.hpc.mil/>

[2] Army Research Laboratory (ARL) MSRC: <http://www.arl.hpc.mil/>

- [3] Aeronautical Systems Center (ASC) MSRC: <http://www.asc.hpc.mil/>  
 [4] Engineer Research and Development Center (ERDC) MSRC: <http://www.erdhpc.mil/>  
 [5] Naval Oceanographic Office (NAVO) MSRC: <http://www.navo.hpc.mil/>

10) Module learning objectives

- a) T5.1 List the key facilities which support DoD M&S T&E (Major Shared Resource Centers).
- b) T5.2 Describe the missions of the key facilities which support DoD M&S T&E.
- c) T5.3 List and link the principle DoD customers to the key facilities which support DoD M&S T&E.
- d) T5.4 Update and list current capabilities (strengths and weaknesses) of the key facilities which support DoD M&S T&E.
- e) T5.5 Predict improvement and modernization activities of the key facilities which support DoD M&S T&E.
- f) T5.6 Describe emerging facilities (currently under development) which will support DoD M&S T&E.

11) Course assessment plan In-class questions and immediate responses.

12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)

3. Introduction and Overview of DoD High Performance Computing (HPC)—Describe the origin, history and current organization of the HPC Management Office (HPCMO); T5.1-T5.3; [1]
4. Major Shared Resource Center Overviews—Unique and Joint Capabilities; [1] [2] [3] [4] [5] and describe the roles and capabilities of the Allocated Distribution Centers; T5.4-T5.6; [1]

---

1) Module T5-A M&S T&E Facilities (Application)

2) Coordinators

Dr. Jeff Little, UAH CMSA, 256-824-2351, [jk10001@uah.edu](mailto:jk10001@uah.edu)  
 Dr. Mikel Petty, UAH CMSA, 256-824-4368, [pettym@uah.edu](mailto:pettym@uah.edu)

3) Module description This module depicts the training required for program managers, systems engineers, and T&E workforce members to be able to apply existing and emerging toolsets from the existing M&S T&E facilities used within the DoD.

4) ESRs that the module supports and the corresponding level of mastery  
 T5 Application

- 5) Prerequisites assumed, and corresponding level of mastery None.
- 6) Module maturity Assorted briefings and short courses have been presented at MSRC's since the inception of the HPC Modernization Program (HPCMP) in 1992. Therefore there is a wealth of information and course material available via HPCMP internet sites and offices.
- 7) Number of hours estimated to deliver/teach module 3 hours
- 8) Proposed delivery modality face-to-face, online
- 9) Proposed references and texts (topics refer to these by number)
  - [1] DoD High Performance Computing Modernization Program: <http://www.hpcmo.hpc.mil/>
  - [2] Army Research Laboratory (ARL) MSRC: <http://www.arl.hpc.mil/>
  - [3] Aeronautical Systems Center (ASC) MSRC: <http://www.asc.hpc.mil/>
  - [4] Engineer Research and Development Center (ERDC) MSRC: <http://www.erdhpc.mil/>
  - [5] Naval Oceanographic Office (NAVO) MSRC: <http://www.navo.hpc.mil/>
- 10) Module learning objectives
  - a) T5.1 List the key facilities which support DoD M&S T&E (Major Shared Resource Centers).
  - b) T5.2 Describe the missions of the key facilities which support DoD M&S T&E.
  - c) T5.3 List and link the principle DoD customers to the key facilities which support DoD M&S T&E.
  - d) T5.4 Update and list current capabilities (strengths and weaknesses) of the key facilities which support DoD M&S T&E.
  - e) T5.5 Predict improvement and modernization activities of the key facilities which support DoD M&S T&E.
  - f) T5.6 Describe emerging facilities (currently under development) which will support DoD M&S T&E.
- 11) Course assessment plan In-class questions and immediate responses.
- 12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)
  5. Introduction and Overview of DoD High Performance Computing (HPC)—Describe the origin, history and current organization of the HPC Management Office (HPCMO); T5.1-T5.3; [1]
  6. Major Shared Resource Center Overviews—Unique and Joint Capabilities; [1] [2] [3] [4] [5] and describe the roles and capabilities of the Allocated Distribution Centers ; T5.4; [1]
  7. HPCMO detailed organization and initiatives—Describe the structure and current initiatives related to the Defense Research and Engineering Network (DREN), the

Institutes, Portfolios, and the User Productivity Enhancement and Technology Transfer (PET) program; T5.5-T5.6

---

- 1) Module T5-M M&S T&E Facilities (Mastery)
- 2) Coordinators  
 Dr. Jeff Little, UAH CMSA, 256-824-2351, [jk10001@uah.edu](mailto:jk10001@uah.edu)  
 Dr. Mikel Petty, UAH CMSA, 256-824-4368, [pettym@uah.edu](mailto:pettym@uah.edu)
- 3) Module description This module depicts the training required for program managers, systems engineers, and T&E workforce members to be able to master existing and emerging toolsets from the existing M&S T&E facilities used within the DoD.
- 4) ESRs that the module supports and the corresponding level of mastery  
 T5 Mastery
- 5) Prerequisites assumed, and corresponding level of mastery None
- 6) Module maturity Assorted briefings and short courses have been presented at MSRC's since the inception of the HPC Modernization Program (HPCMP) in 1992. Therefore there is a wealth of information and course material available via HPCMP internet sites and offices.
- 7) Number of hours estimated to deliver/teach module 4 hours
- 8) Proposed delivery modality face-to-face, online
- 9) Proposed references and texts (topics refer to these by number)  
 [1] DoD High Performance Computing Modernization Program:  
<http://www.hpcmo.hpc.mil/>  
 [2] Army Research Laboratory (ARL) MSRC: <http://www.arl.hpc.mil/>  
 [3] Aeronautical Systems Center (ASC) MSRC: <http://www.asc.hpc.mil/>  
 [4] Engineer Research and Development Center (ERDC) MSRC:  
<http://www.erdhpc.mil/>  
 [5] Naval Oceanographic Office (NAVO) MSRC: <http://www.navo.hpc.mil/>
- 10) Module learning objectives
  - a) T5.1 List the key facilities which support DoD M&S T&E (Major Shared Resource Centers).
  - b) T5.2 Describe the missions of the key facilities which support DoD M&S T&E.
  - c) T5.3 List and link the principle DoD customers to the key facilities which support DoD M&S T&E.
  - d) T5.4 Update and list current capabilities (strengths and weaknesses) of the key facilities which support DoD M&S T&E.



- e) T5.5 Predict improvement and modernization activities of the key facilities which support DoD M&S T&E.
- f) T5.6 Describe emerging facilities (currently under development) which will support DoD M&S T&E.

11) Course assessment plan In-class questions and immediate responses as well as a summary report in PowerPoint format of group brainstorming results.

12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)

- 8. Introduction and Overview of DoD High Performance Computing (HPC)—Describe the origin, history and current organization of the HPC Management Office (HPCMO); T5.1-T5.3; [1]
- 9. Major Shared Resource Center Overviews—Unique and Joint Capabilities; [1] [2] [3] [4] [5] and describe the roles and capabilities of the Allocated Distribution Centers; T5.4; [1]
- 10. HPCMO detailed organization and initiatives—Describe the structure and current initiatives related to the Defense Research and Engineering Network (DREN), the Institutes, Portfolios, and the User Productivity Enhancement and Technology Transfer (PET) program; T5.5
- 11. Case study exercise—In a group setting brainstorm future DoD HPC needs and suggestions for HPC initiatives; T5.6

**O1) Describe the use of operational and logistical models across the acquisition life cycle.**

- 1) Module name: Analytical Models for Operational and Logistic Applications
- 2) Module coordinator: Marsha Taliaferro-Gillis, Ph.D.  
6596 Main Street  
Gloucester, VA 23061  
(804)694-3173 (Office)  
(804)824-4663 (Cell)  
mtgillis@werneranderson.com
- 3) Module description: Understand the application of analytical models for operations and logistic applications across the acquisition life cycle.
- 4) ESRs that the module supports: O1
- 5) Prerequisites assumed, and corresponding level of mastery:
- 6) Module maturity: none
- 7) Number of hours estimated to teach: 25
- 8) Proposed Delivery modality: face-to-face, on-line, VTC, resident, customer's site
- 9) Proposed references and texts:

CJCSI 3170.01

DoD 5000.1, 5000.2

Test & Evaluation Management Guide

Defense Acquisition Guidebook

Kress, Moshe. 2002. *Operational Logistics: The Art and Science of Sustaining Military Operations*. Massachusetts: Kluwer Academic Publishers.

VV&A Recommended Practices Guide

- 10) Module learning objectives:
  - O1.1 Identify the acquisition cycle milestones and events supported by logistics and operational modeling applications.

- O1.2 Understand the use of logistics and operational models in support of concept refinement by rapid prototyping.
- O1.3 Understand the use of logistics and operational models in support of system development & demonstration to support system of systems and family of systems evaluations, to focus test and evaluation, and to support transfer to production.
- O1.4 Understand how the use of logistics and operational models in support technology development reduces technology risks, allows the early evaluation of RM&A, transportability, and provisioning, and supports test & evaluation.
- O1.5 Understand the use of logistics and operational models in support of production & deployment to streamline production and to support the development of trainers.
- O1.6 Understand the use of logistics and operational models in support of operations and support to refine system design and identify future requirements.
- O1.7 Describe types of operations analyses and the levels of detail typically included in these analyses (e.g., system, engagement, mission, campaign).
- O1.8 Describe types of logistics analyses (technical effectiveness, system effectiveness, system availability, operational availability, operational reliability, response time, work load allocation, and supply chain management) and the levels of detail typically included in these analyses.
- O1.9 Describe the role of modeling inputs and assumptions in developing a logistics and an operational analysis (scenario & threat, missions, alternatives, required input data, operations concept, basing & deployment, support concept, [MAIS AoA: organizational missions, functions, & objective]).
- O1.10 Given a case study and a sample M&S Support Plan, assess the effectiveness of the M&S Support Plan in integrating M&S use throughout the life-cycle of the program through M&S reuse and the building of better models through the model–test-model.
- O1.11 Given a case study, assess how models developed during the acquisition process can be used to support course-of-action, decision support, and training.

11) Course assessment plan: projects, and exams

12) Topic list by hour of instruction and reference.

*Competency Level: General Awareness*

- i) Hour 1: Identify the acquisition cycle milestones and events supported by logistics and operational modeling applications.
  - o Acquisition life cycle
    - DoD 5000.1 & 2
    - CJCSI 3170.01

*Competency Level: General Awareness*

- ii) Hour 2: Understand the use of logistics and operational models in support of concept refinement by rapid prototyping.
  - Concept Refinement
  - M&S in Concept refinement
- DoD 5000.2
- Defense Acquisition Guidebook, Section 4.3.1.1, 4.5.7.1  
M&S in Concept Refinement

*Competency Level: Understanding*

- iii) Hour 3: Understand the use of logistics and operational models in support of concept refinement by rapid prototyping.
  - Concept Refinement
  - M&S in Concept refinement
- DoD 5000.2
- Defense Acquisition Guidebook, Section 4.3.1.1, 4.5.7.1  
M&S in Concept Refinement

*Competency Level: General Awareness*

- iv) Hour 4: Understand the use of logistics and operational models in support of system development & demonstration to support system of systems and family of systems evaluations, to focus test and evaluation, and to support transfer to production.
  - System Development & Demonstration
  - M&S in System Development and Demonstration
- DoD 5000.2
- Defense Acquisition Guidebook, Section 4.3.3.6, 4.5.7.3

*Competency Level: Understanding*

- v) Hour 5: Understand the use of logistics and operational models in support of system development & demonstration to support system of systems and family of systems evaluations, to focus test and evaluation, and to support transfer to production.
  - System Development & Demonstration
  - M&S in System Development and Demonstration
- DoD 5000.2
- Defense Acquisition Guidebook, Section 4.3.3.6, 4.5.7.3

*Competency Level: General Awareness*

- vi) Hour 6: Understand how the use of logistics and operational models in support technology development reduces technology risk, allows the early evaluation of RM&A, transportability, and provisioning, and supports test & evaluation.
  - Technology Risk
  - RM&A

- Transportability, Provisioning
- Test & Evaluation Management Guide

*Competency Level: Understanding*

vii) Hour 7: Understand how the use of logistics and operational models in support technology development reduces technology risk, allows the early evaluation of RM&A, transportability, and provisioning, and supports test & evaluation.

- Technology Risk
- RM&A
- Transportability, Provisioning
- Test & Evaluation Management Guide

*Competency Level: General Awareness*

viii) Hour 8: Understand the use of logistics and operational models in support of production & deployment to streamline production and to support the development of trainers.

- Production
- M&S in Training
- Test & Evaluation Management Guide

*Competency Level: Understanding*

ix) Hour 9: Understand the use of logistics and operational models in support of production & deployment to streamline production and to support the development of trainers.

- Production
- M&S in Training
- Test & Evaluation Management Guide

*Competency Level: General Awareness*

x) Hour 10: Understand the use of logistics and operational models in support of operations and support to refine system design and identify future requirements.

- Forecasting Logistic Demands
- Kress, Moshe. *Operational Logistics: The Art and Science of Sustaining Military Operations*. 2002. Massachusetts: Kluwer Academic Publishers.

*Competency Level: Understanding*

xi) Hour 11: Understand the use of logistics and operational models in support of operations and support to refine system design and identify future requirements.

- Forecasting Logistic Demands
- Kress, Moshe. *Operational Logistics: The Art and Science of Sustaining Military Operations*. 2002. Massachusetts: Kluwer Academic Publishers.

*Competency Level: General Awareness*

xii) Hour 12: Describe types of operations analyses and the levels of detail typically included in these analyses (e.g., system, engagement, mission, campaign).

- Operational analyses
- Define system, engagement, mission, campaign levels of models

*Competency Level: General Awareness*

xiii) Hour 13: Describe types of operations analyses and the levels of detail typically included in these analyses (e.g., system, engagement, mission, campaign).

- Operational analyses
- Define system, engagement, mission, campaign levels of models
- Kress, Moshe. *Operational Logistics: The Art and Science of Sustaining Military Operations*. 2002. Massachusetts: Kluwer Academic Publishers.

*Competency Level: General Awareness*

xiv) Hour 14: Describe types of operations analyses and the levels of detail typically included in these analyses (e.g., system, engagement, mission, campaign).

- Operational analyses
- Define system, engagement, mission, campaign levels of models
- Kress, Moshe. *Operational Logistics: The Art and Science of Sustaining Military Operations*. 2002. Massachusetts: Kluwer Academic Publishers.

*Competency Level: General Awareness*

xv) Hour 15: Describe types of logistics analyses (technical effectiveness, system effectiveness, system availability, operational availability, operational reliability, response time, workload allocation, and supply chain management) and the levels of detail typically included in these analyses.

- Logistics analysis
- Levels of detail
- Kress, Moshe. *Operational Logistics: The Art and Science of Sustaining Military Operations*. 2002. Massachusetts: Kluwer Academic Publishers.

*Competency Level: General Awareness*

xvi) Hour 16: Describe types of logistics analyses (technical effectiveness, system effectiveness, system availability, operational availability, operational reliability, response time, workload allocation, and supply

chain management) and the levels of detail typically included in these analyses.

- Logistics analysis
- Levels of detail
- Kress, Moshe. *Operational Logistics: The Art and Science of Sustaining Military Operations*. 2002. Massachusetts: Kluwer Academic Publishers.

*Competency Level: General Awareness*

xvii) Hour 17: Describe types of logistics analyses (technical effectiveness, system effectiveness, system availability, operational availability, operational reliability, response time, workload allocation, and supply chain management) and the levels of detail typically included in these analyses.

- Logistics analysis
- Levels of detail
- Kress, Moshe. *Operational Logistics: The Art and Science of Sustaining Military Operations*. 2002. Massachusetts: Kluwer Academic Publishers.

*Competency Level: General Awareness*

xviii) Hour 18: Describe the role of modeling inputs and assumptions in developing a logistics and an operational analysis (scenario & threat, missions, alternatives, required input data, operations concept, basing & deployment, support concept, [MAIS AoA: organizational missions, functions, & objective]).

- Modeling inputs and assumptions
- DoD 5000.59

*Competency Level: General Awareness*

xix) Hour 19: Describe the role of modeling inputs and assumptions in developing a logistics and an operational analysis (scenario & threat, missions, alternatives, required input data, operations concept, basing & deployment, support concept, [MAIS AoA: organizational missions, functions, & objective]).

- Modeling inputs and assumptions
- DoD 5000.59

*Competency Level: Application*

xx) Hour 20: Given a case study and a sample M&S Support Plan, assess the effectiveness of the M&S Support Plan in integrating M&S use throughout the lifecycle of the program through M&S reuse and the building of better models through the model-test-model approach.

- M&S Management
- DoD 5000.59

*Competency Level: Mastery*

- xxi) Hour 21: Given a case study and a sample M&S Support Plan, assess the effectiveness of the M&S Support Plan in integrating M&S use throughout the lifecycle of the program through M&S reuse and the building of better models through the model-test-model approach.
- Model- Test-Model
  - M&S Reuse
  - Test & Evaluation Management Guide
  - VV&A Recommended Practices Guide

*Competency Level: Mastery*

- xxii) Hour 22: Given a case study and a sample M&S Support Plan, assess the effectiveness of the M&S Support Plan in integrating M&S use throughout the lifecycle of the program through M&S reuse and the building of better models through the model-test-model approach.
- Model- Test-Model
  - M&S Reuse
  - Test & Evaluation Management Guide
  - VV&A Recommended Practices Guide

*Competency Level: Application*

- xxiii) Hour 23: Given a case study, assess how models developed during the acquisition process can be used to support course-of-action, decision support, and training.
- Model- Test-Model
  - M&S Reuse
  - Test & Evaluation Management Guide
  - VV&A Recommended Practices Guide

*Competency Level: Mastery*

- xxiv) Hour 24: Given a case study, assess how models developed during the acquisition process can be used to support course-of-action, decision support, and training.
- Model- Test-Model
  - M&S Reuse
  - Test & Evaluation Management Guide
  - VV&A Recommended Practices Guide

*Competency Level: Mastery*

- xxv) Hour 25: Given a case study, assess how models developed during the acquisition process can be used to support course-of-action, decision support, and training.
- Model- Test-Model
  - M&S Reuse
  - Test & Evaluation Management Guide
  - VV&A Recommended Practices Guide



**O2) Know the properties of a representative suite of operational models across the services.**

- a. Required inputs**
- b. Outputs**
- c. Assumptions**
- d. Implementation requirements**
- e. Costs**
- f. Time required**
- g. Adaptability and extensibility**
- h. VVA status**

- 1) Module name: Operational Models
- 2) Module coordinator: Marsha Taliaferro-Gillis, Ph.D.  
6596 Main Street  
Gloucester, VA 23061  
(804)694-3173 (Office)  
(804)824-4663 (Cell)  
mtgillis@werneranderson.com
- 3) Module description: Know the properties of a representative suite of operational models across the services.
- 4) ESRs that the module supports: O2
- 5) Prerequisites assumed, and corresponding level of mastery:
- 6) Module maturity: none
- 7) Number of hours estimated to teach: 16
- 8) Proposed Delivery modality: face-to-face, on-line, VTC, resident, customer's site
- 9) Proposed references and texts:

Altioik, T., B. Melamed. 2007. *Simulation Modeling and Analysis with ARENA*, Academic Press, Burlington, MA.

Hammonds, P., B. Zeigler. 2007. *Modeling and Simulation - Based Data Engineering: Introducing Pragmatics into Ontologies for Net-Centric Information Exchange*, Burlington, MA.

Kelton, W., A. Law. 2000. *Simulation Modeling and Analysis*, 3rd ed. McGraw-Hill, Boston, MA.

Kress, M. 2002. *Operational Logistics: The Art and Science of Sustaining Military Operations*, 1st ed. Springer, Norwell, MA.

Mackenzie, G., G. Schulmeyer, L. Yilmaz. 2002. *Verification Technology Potential with Different Modeling and Simulation Development and Implementation Paradigms*. Working paper, John Hopkins University Applied Physics Laboratory, Laurel, Maryland.

10) Module learning objectives:

- O2.1 Identify levels of detail typically included operational analyses (e.g., system, engagement, mission, campaign)
- O2.2 Identify prospective operational models from a list of models.
- O2.3 Identify levels of detail typically included in operational analyses.
- O2.4 Understand the role of aggregation and disaggregation across operational levels of detail.
- O2.5 Understand the importance of developing quantifiable metrics of performance to meet mission requirements affordably.
- O2.6 Understand the difference in data requirements at different levels of abstraction
- O2.7 Describe the role of modeling inputs and assumptions in developing operational analysis (scenario & threat, missions, alternatives, required input data, operations concept, basing & deployment, support concept, [MAIS AoA: organizational missions, functions, & objectives]).
- O2.8 Understand the importance of sensitivity analysis of critical assumptions in determine solution outputs.
- O2.9 Given a case study, assess the effectiveness of a sample suite of operational models in evaluating the full range of operational requirements (reliability, effectiveness, logistics footprint, supportability).

11) Course assessment plan: projects, and exams

12) Topic list by hour of instruction and reference.

*Competency Level: General Awareness*

- i) Hour 1: Identify levels of detail typically included in operational analyses
  - detail needed for operational analyses
  - simulation model development life cycle
  - Kelton, W., A. Law. 2000. *Simulation Modeling and Analysis*, 3rd ed. McGraw-Hill, Boston, MA.
  - Mackenzie, G., G. Schulmeyer, L. Yilmaz. 2002. *Verification Technology Potential with Different Modeling and Simulation Development and Implementation Paradigms*. Working paper, John Hopkins University Applied Physics Laboratory, Laurel, Maryland.

*Competency Level: General Awareness*

- ii) Hour 2: Identify prospective operational models from a list of models.
  - operational model
  - Kelton, W., A. Law. 2000. *Simulation Modeling and Analysis*, 3rd ed. McGraw-Hill, Boston, MA.
  - Model library to develop list of models

*Competency Level: General Awareness*

- iii) Hour 3: Identify levels of detail typically included in system, engagement, mission, and campaign.
  - Kelton, W., A. Law. 2000. *Simulation Modeling and Analysis*, 3rd ed. McGraw-Hill, Boston, MA.

*Competency Level: General Awareness*

- iv) Hour 4: Understand the role of aggregation and disaggregation across operational levels of detail.
  - aggregation and disaggregation in operational details
  - Kress, M. 2002. *Operational Logistics: The Art and Science of Sustaining Military Operations*, 1st ed. Springer, Norwell, MA.

*Competency Level: Understanding*

- v) Hour 5: Understand the role of aggregation and disaggregation across operational levels of detail.
  - aggregation and disaggregation in operational details
  - Kress, M. 2002. *Operational Logistics: The Art and Science of Sustaining Military Operations*, 1st ed. Springer, Norwell, MA.

*Competency Level: General Awareness*

- vi) Hour 6: Understand the importance of developing quantifiable metrics of performance to meet mission requirements affordably.
  - importance of quantifiable metrics of performance
  - affordability of mission requirements
  - Kress, M. 2002. *Operational Logistics: The Art and Science of Sustaining Military Operations*, 1st ed. Springer, Norwell, MA.

*Competency Level: Understanding*

- vii) Hour 7: Understand the importance of developing quantifiable metrics of performance to meet mission requirements affordably.
  - importance of quantifiable metrics of performance
  - affordability of mission requirements

- Kress, M. 2002. *Operational Logistics: The Art and Science of Sustaining Military Operations*, 1st ed. Springer, Norwell, MA.

*Competency Level: General Awareness*

- viii) Hour 8: Understand the difference in data requirements at different levels of abstraction
  - data requirement differences at different levels of abstraction
- Kress, M. 2002. *Operational Logistics: The Art and Science of Sustaining Military Operations*, 1st ed. Springer, Norwell, MA.

*Competency Level: Understanding*

- ix) Hour 9: Understand the difference in data requirements at different levels of abstraction
  - data requirement differences at different levels of abstraction
- Kress, M. 2002. *Operational Logistics: The Art and Science of Sustaining Military Operations*, 1st ed. Springer, Norwell, MA.

*Competency Level: General Awareness*

- x) Hour 10: Describe the role of modeling inputs and assumptions in developing operational analysis (scenario & threat, missions, alternatives, required input data, operations concept, basing & deployment, support concept, [MAIS AoA: organizational missions, functions, & objectives]).
  - modeling input and assumptions for developing operation analysis across all missions, functions and objectives.
- Altiok, T., B. Melamed. 2007. *Simulation Modeling and Analysis with ARENA*, Academic Press, Burlington, MA

*Competency Level: General Awareness*

- xi) Hour 11: Describe the role of modeling inputs and assumptions in developing operational analysis (scenario & threat, missions, alternatives, required input data, operations concept, basing & deployment, support concept, [MAIS AoA: organizational missions, functions, & objectives]).
  - modeling input and assumptions for developing operation analysis across all missions, functions and objectives
- Kress, M. 2002. *Operational Logistics: The Art and Science of Sustaining Military Operations*, 1st ed. Springer, Norwell, MA.

*Competency Level: General Awareness*

xii) Hour 12: Understand the importance of sensitivity analysis of critical assumptions in determining solution outputs.

- review of Basic Probability and Statistics
- sensitivity analysis of critical assumptions for solution outputs
- Kelton, W., A. Law. 2000. *Simulation Modeling and Analysis*, 3rd ed. McGraw-Hill, Boston, MA.

*Competency Level: Understanding*

xiii) Hour 13: Understand the importance of sensitivity analysis of critical assumptions in determining solution outputs for operations.

- sensitivity analysis of critical assumptions for operational solutions
- output analysis
- Altioik, T., B. Melamed. 2007. *Simulation Modeling and Analysis with ARENA*, Academic Press, Burlington, MA

*Competency Level: Application*

xiv) Hour 14: Given a case study, assess the effectiveness of a sample suite of operational models in evaluating the full range of operational requirements (reliability, effectiveness, operational footprint, supportability criteria etc.) to sustain the mission on long term.

- Testing In a Net-Centric Environment: Multiple Levels
- reliability
- effectiveness
- logistics footprint
- Hammonds, P., B. Zeigler. 2007. *Modeling and Simulation - Based Data Engineering: Introducing Pragmatics into Ontologies for Net-Centric Information Exchange*, Burlington, MA.

*Competency Level: Mastery*

xv) Hour 15: Given a case study, assess the effectiveness of a sample suite of operational models in evaluating the full range of operational requirements (reliability, effectiveness, logistics footprint, supportability criteria, etc.) to sustain the mission on long term.

- Hammonds, P., B. Zeigler. 2007. *Modeling and Simulation - Based Data Engineering: Introducing Pragmatics into Ontologies for Net-Centric Information Exchange*, Burlington, MA.

*Competency Level: Mastery*

- xvi) Hour 16: Given a case study, assess the effectiveness of a sample suite of operational models in evaluating the full range of operational requirements (reliability, effectiveness, logistics footprint, supportability criteria, etc). to sustain the mission on long term.
- Hammonds, P., B. Zeigler. 2007. *Modeling and Simulation - Based Data Engineering: Introducing Pragmatics into Ontologies for Net-Centric Information Exchange*, Burlington, MA.

**O3) Know the properties of a representative suite of logistical models across the services.**

- i. Required inputs**
- j. Outputs**
- k. Assumptions**
- l. Implementation requirements**
- m. Costs**
- n. Time required**
- o. Adaptability and extensibility**
- p. VVA status**

- 1) Module name: Logistics Modeling
- 2) Module coordinator: Marsha Taliaferro-Gillis, Ph.D.  
6596 Main Street  
Gloucester, VA 23061  
(804)694-3173 (Office)  
(804)824-4663 (Cell)  
mtgillis@werneranderson.com
- 3) Module description: Know the properties of a representative suite of logistics models across the services.
  - a. Required Input
  - b. Outputs
  - c. Assumptions
  - d. Implementation Requirements
  - e. Costs
  - f. Time Required
  - g. Adaptability and Extensibility
  - h. VVA Status
- 4) ESR that the module supports: O3
- 5) Prerequisites assumed, and corresponding level of mastery:
- 6) Module maturity: none
- 7) Number of hours estimated to teach module: 16
- 8) Proposed Delivery modality: face-to-face, on-line, VTC, resident, customer's site
- 9) Proposed references and texts:

Altioik, T., B. Melamed. 2007. *Simulation Modeling and Analysis with ARENA*, Academic Press, Burlington, MA.

Kelton, W., A. Law. 2000. *Simulation Modeling and Analysis*, McGraw-Hill, Boston, MA.

Kress, M. 2002. *Operational Logistics: The Art and Science of Sustaining Military Operations*, 1st ed. Springer, Norwell, MA.

Hammonds, P., B. Zeigler 2007. *Modeling and Simulation - Based Data Engineering: Introducing Pragmatics Into Ontologies for Net-Centric Information Exchange*, Burlington, MA

10) Module learning objectives:

- O3.1 Identify levels of detail typically included logistics analyses.
- O3.2 Identify prospective logistics models from a list of models.
- O3.3 Identify levels of detail typically included in logistics analyses.
- O3.4 Understand the role of aggregation across logistical levels of detail.
- O3.5 Understand the importance of developing quantifiable metrics of performance to meet mission requirements affordably
- O3.6 Understand the difference in data requirements at different levels of abstraction
- O3.7 Describe the role of modeling inputs and assumptions in developing operational analysis (scenario & threat, missions, alternatives, required input data, operations concept, basing & deployment, support concept, [MAIS AoA: organizational missions, functions, & objective]).
- O3.8 Understand the importance of sensitivity analysis of critical assumptions in determine solution outputs.
- O3.9 Given a case study, assess the effectiveness of a sample suite of logistical models in evaluating the full range of logistical requirements (reliability, effectiveness, logistics footprint, supportability criteria, etc.) to sustain the mission over long term.

11) Course assessment plan: projects, and exams

12) Topic list by hour of instruction and reference:

*Competency Level: General Awareness*

- i) Hour one: Identify levels of detail typically included in logistics analyses.
  - o level of detail needed in logistics models
  - Kelton, W., A. Law. 2000. *Simulation Modeling and Analysis*, McGraw-Hill, Boston, MA.

*Competency Level: General Awareness*

- ii) Hour two: Identify prospective logistics models from a list of models.
  - o prospective logistics models
  - Kelton, W., A. Law. 2000. *Simulation Modeling and Analysis*, McGraw-Hill, Boston, MA.



- Altiook, T., B. Melamed. 2007. *Simulation Modeling and Analysis with ARENA*, Academic Press, Burlington, MA.

*Competency Level: General Awareness*

iii) Hour three: Identify levels of detail typically included in logistics analyses.

- typical detail level in logistics analyses
- Kelton, W., A. Law. 2000. *Simulation Modeling and Analysis*, McGraw-Hill, Boston, MA.

*Competency Level: General Awareness*

iv) Hour four: Understand the role of aggregation across logistical levels of detail.

- aggregation in logistical levels of details
- Altiook, T., B. Melamed. 2007. *Simulation Modeling and Analysis with ARENA*, Academic Press, Burlington, MA.

*Competency Level: Understanding*

v) Hour five: Understand the role of aggregation across logistical levels of detail.

- aggregation in logistical levels of details
- Kress, M. 2002. *Operational Logistics: The Art and Science of Sustaining Military Operations*, 1st ed. Springer, Norwell, MA.

*Competency Level: General Awareness*

vi) Hour six: Understand the importance of developing quantifiable metrics of performance to meet mission requirements affordably

- quantifiable metrics for affordable mission requirements
- Kress, M. 2002. *Operational Logistics: The Art and Science of Sustaining Military Operations*, 1st ed. Springer, Norwell, MA.

*Competency Level: Understanding*

vii) Hour seven: Understand the importance of developing quantifiable metrics of performance to meet mission requirements affordably

- quantifiable metrics for affordable mission requirements
- Kelton, W., A. Law. 2000. *Simulation Modeling and Analysis*, McGraw-Hill, Boston, MA.

*Competency Level: General Awareness*

viii) Hour eight: Understand the difference in data requirements at different levels of abstraction

- data requirements at different levels of abstraction

*Competency Level: Understanding*

ix) Hour nine: Understand the difference in data requirements at different levels of abstraction

- data requirements at different levels of abstraction
- Kelton, W., A. Law. 2000. *Simulation Modeling and Analysis*, McGraw-Hill, Boston, MA.

*Competency Level: General Awareness*

x) Hour ten: Describe the role of modeling inputs and assumptions in developing operational analysis (scenario & threat, missions, alternatives, required input data, logistics concept, basing & deployment, support concept, [MAIS AoA: organizational missions, functions, & objective]).

- modeling inputs and assumptions for developing logistical analysis across all mission, functions, concepts, and objectives
- Altiock, T., B. Melamed. 2007. *Simulation Modeling and Analysis with ARENA*, Academic Press, Burlington, MA.

*Competency Level: General Awareness*

xi) Hour eleven: Describe the role of modeling inputs and assumptions in developing operational analysis (scenario & threat, missions, alternatives, required input data, operations concept, basing & deployment, support concept, [MAIS AoA: organizational missions, functions, & objective])

- modeling inputs and assumptions for developing logistical analysis across all mission, functions, concepts, and objectives
- Altiock, T., B. Melamed. 2007. *Simulation Modeling and Analysis with ARENA*, Academic Press, Burlington, MA.

*Competency Level: General Awareness*

xii) Hour twelve: Understand the importance of sensitivity analysis of critical assumptions in determining solution outputs for logistics.

- sensitivity analysis of critical assumptions for logistical solution outputs.
- Kelton, W., A. Law. 2000. *Simulation Modeling and Analysis*, McGraw-Hill, Boston, MA.

*Competency Level: Understanding*

xiii) Hour thirteen: Understand the importance of sensitivity analysis of critical assumptions in determining solution outputs for logistics.

- sensitivity analysis of critical assumptions for logistical solution outputs.
- Altiock, T., Melamed, B., 2007. *Simulation Modeling and Analysis with ARENA*, Academic Press, Burlington, MA.

*Competency Level: Application*

- xiv) Hour fourteen: Given a case study, assess the effectiveness of a sample suite of logistical models in evaluating the full range of logistical requirements (reliability, effectiveness, logistics footprint, supportability criteria, etc.) to sustain the mission over long term
  - assess effectiveness of a sample of logistical models in evaluating requirements to sustain long term missions
- Kress M., 2002. *Operational Logistics: The Art and Science of Sustaining Military Operations*, 1st ed. Springer, Norwell, MA.

*Competency Level: Mastery*

- xv) Hour fifteen: Given a case study, assess the effectiveness of a sample suite of logistical models in evaluating the full range of logistical requirements (reliability, effectiveness, logistics footprint, supportability criteria, etc.) to sustain the mission over long term
  - assess effectiveness of a sample of logistical models in evaluating requirements to sustain long term missions
- Kress, M. 2002. *Operational Logistics: The Art and Science of Sustaining Military Operations*, 1st ed. Springer, MA.

*Competency Level: Mastery*

- xvi) Hour sixteen: Given a case study, assess the effectiveness of a sample suite of logistical models in evaluating the full range of logistical requirements (reliability, effectiveness, logistics footprint, supportability criteria, etc.) to sustain the mission over long term
  - assess effectiveness of a sample of logistical models in evaluating requirements to sustain long term missions
- Hammonds, P., B. Zeigler 2007. *Modeling and Simulation - Based Data Engineering: Introducing Pragmatics Into Ontologies for Net-Centric Information Exchange*, Burlington, MA

**O4) Select appropriate level of abstraction and fidelity for an operational and logistical model.**

- 1) Module name: Abstractions and Lower levels of Realism
- 2) Module coordinator: Marsha Taliaferro-Gillis, Ph.D.  
6596 Main Street  
Gloucester, VA 23061  
(804)694-3173 (Office)  
(804)824-4663 (Cell)  
mtgillis@werneranderson.com
- 3) Module description: Select appropriate level of abstraction and fidelity for an operational and logistical model.
- 4) ESRs that the module supports: O4
- 5) Prerequisites assumed, and corresponding level of mastery:
- 6) Module maturity: none
- 7) Number of hours estimated to teach: 22
- 8) Proposed Delivery modality: face-to-face, on-line, VTC, resident, customer's site
- 9) Proposed references and texts:

Boyson, S., Harrington, L., T. M. Corsi, 2004. *In Real Time: Managing the New Supply Chain*. Praeger Publishers, Westport, CT.

Greasley, A. 2004. *Simulation Modeling for Business*. Ashgate Publishing Limited, Burling, VT.

Kress, J. 2002 . *Operational Logistics: The Art and Science of Sustaining Military Operations*. Kluwer Academic Publishers, Norwell, MA.

Law, A. M., D. W. Kelton, 2000. *Simulation Modeling and Analysis*. The McGraw-Hill Companies, Inc., Boston, MA.

Lewis, R. O., 1992, *Independent Verification and Validation*. John Wiley & Sons, Inc, Canada.

Rubinstein, R., B. Melamed. 1998. *Modern Simulation and Modeling*. John Wiley & Sons, Inc, Canada.

## 10) Module learning objectives:

- O4.1 Describe types of operational and logistics analyses (technical effectiveness, system effectiveness, system availability, operational availability, operational reliability, response time, workload allocation, and supply chain management) and the levels of detail typically.
- O4.2 Understand the role of aggregation and disaggregation across operational and logistical levels of detail.
- O4.3 Understand the quantifiable metrics available at varying levels of abstraction and realism.
- O4.4 Understand the difference in data requirements at different levels of abstraction.
- O4.5 Describe the role of modeling inputs and assumptions in developing an operational or logistics analysis (scenario & threat, missions, alternatives, required input data, operations concept, basing & deployment, support concept, [MAIS AoA: organizational missions, functions, & objectives]).
- O4.6 Understand the importance of sensitivity analysis of critical assumptions in determine solution outputs.
- O4.7 Given a case study, assess how differences between levels of abstraction support different the different phases of the acquisition cycle.
- O4.8 Given a case study, evaluate the impact of different levels of abstraction on verification and validation.

## 11) Course assessment plan: projects, and exams

## 12) Topic list by hour of instruction and reference.

*Competency Level: General Awareness*

- i) Hour one: Describe types of operational and logistics analyses (technical effectiveness, system effectiveness, system availability, operational availability, operational reliability, response time, workload allocation, and supply chain management) and the levels of detail typically.
  - technical effectiveness
  - operational logistics
  - strategic logistics
  - tactical logistics
- Kress, J. 2002 .*Operational Logistics: The Art and Science of Sustaining Military Operations*. Kluwer Academic Publishers, Norwell, MA.

*Competency Level: General Awareness*

- ii) Hour two: Describe types of operational and logistics analyses (technical effectiveness, system effectiveness, system availability, operational availability, operational reliability, response time, workload allocation, and supply chain management) and the levels of detail typically.

- response time
- workload allocation
- supply chain management
- level of detail
- Kress, J. 2002 .*Operational Logistics: The Art and Science of Sustaining Military Operations*. Kluwer Academic Publishers, Norwell, MA.

*Competency Level: General Awareness*

- iii) Hour three: Understand the role of aggregation and disaggregation across operational and logistical levels of detail.
  - technical effectiveness
  - system effectiveness
  - system availability
  - operational reliability
  - model aggregation in operations and logistics
- Kress, J. 2002 .*Operational Logistics: The Art and Science of Sustaining Military Operations*. Kluwer Academic Publishers, Norwell, MA.

*Competency Level: Understanding*

- iv) Hour four: Understand the role of aggregation and disaggregation across operational and logistical levels of detail
  - model disaggregation in operations and logistics
  - guidelines for determining the level of model detail
- Lewis, R. O. 1992. *Independent Verification and Validation*. John Wiley & Sons, Inc, Canada.

*Competency Level: Understanding*

- v) Hour five: Understand the role of aggregation and disaggregation across operational and logistical levels of detail.
  - model disaggregation in operations and logistics
  - guidelines for determining the level of model detail
- Lewis, R. O. 1992. *Independent Verification and Validation*. John Wiley & Sons, Inc, Canada.

*Competency Level: General Awareness*

- vi) Hour six: Understand the quantifiable metrics available at varying levels of abstraction and realism.
  - metrics
  - levels of abstraction and realism
  - selecting input probability distributions
- Lewis, R. O. 1992. *Independent Verification and Validation*. John Wiley & Sons, Inc, Canada.

*Competency Level: Understanding*

- vii) Hour seven: Understand the quantifiable metrics available at varying levels of abstraction and realism.
  - probability
  - Lewis, R. O. 1992. *Independent Verification and Validation*. John Wiley & Sons, Inc, Canada.

*Competency Level: General Awareness*

- viii) Hour eight: Understand the difference in data requirements at different levels of abstraction.
  - response time
  - workload allocation
  - supply chain management
  - level of detail
  - Kress, J. 2002 .*Operational Logistics: The Art and Science of Sustaining Military Operations*. Kluwer Academic Publishers, Norwell, MA.

*Competency Level: Understanding*

- ix) Hour nine: Understand the difference in data requirements at different levels of abstraction.
  - response time
  - workload allocation
  - supply chain management
  - level of detail
  - Kress, J. 2002 .*Operational Logistics: The Art and Science of Sustaining Military Operations*. Kluwer Academic Publishers, Norwell, MA.

*Competency Level: General Awareness*

- x) Hour ten: Describe the role of modeling inputs and assumptions in developing an operational or logistics analysis (scenario & threat, missions, alternatives, required input data, operations concept, basing & deployment, support concept, [MAIS AoA: organizational missions, functions, & objectives]).
  - logistical analysis
  - Kress, J. 2002 .*Operational Logistics: The Art and Science of Sustaining Military Operations*. Kluwer Academic Publishers, Norwell, MA.

*Competency Level: General Awareness*

- xi) Hour eleven: Describe the role of modeling inputs and assumptions in developing an operational or logistics analysis (scenario & threat, missions, alternatives, required input data, operations concept, basing & deployment, support concept, [MAIS AoA: organizational missions, functions, & objectives]).

- tactical levels
- responsiveness in operations
- Kress, J. 2002 .*Operational Logistics: The Art and Science of Sustaining Military Operations*. Kluwer Academic Publishers, Norwell, MA.

*Competency Level: General Awareness*

- xii) Hour twelve: Understand the importance of sensitivity analysis of critical assumptions in determine solution outputs.
  - inputs and outputs
  - input analysis using tes sequence
- Rubinstein, R., B. Melamed. 1998. *Modern Simulation and Modeling*. John Wiley & Sons, Inc, Canada.

*Competency Level: Understanding*

- xiii) Hour thirteen: Understand the importance of sensitivity analysis of critical assumptions in determine solution outputs.
  - real-time visualization and modeling of supply chains
- Boyson, S., Harrington, L., T. M. Corsi, 2004. In *Real Time: Managing the New Supply Chain*. Praeger Publishers, Westport, CT.

*Competency Level: Understanding*

- xiv) Hour fourteen: Understand the importance of sensitivity analysis of critical assumptions in determine solution outputs.
  - inputs and outputs
  - input analysis using tes sequence
- Rubinstein, R., B. Melamed. 1998. *Modern Simulation and Modeling*. John Wiley & Sons, Inc, Canada., pg. 51

*Competency Level: Application*

- xv) Hour fifteen: Understand the importance of sensitivity analysis of critical assumptions in determine solution outputs.
  - inputs and outputs
  - input analysis using tes sequence
- Rubinstein, R., B. Melamed. 1998. *Modern Simulation and Modeling*. John Wiley & Sons, Inc, Canada., pg. 51

*Competency Level: Mastery*

- xvi) Hour sixteen: Given a case study, assess how differences between levels of abstraction support different the different phases of the acquisition cycle.
  - a large data-acquisition system
- Lewis, R. O. 1992. *Independent Verification and Validation*. John Wiley & Sons Inc, Canada, pg 32



*Competency Level: Mastery*

- xvii) Hour seventeen: Given a case study, assess how differences between levels of abstraction support different the different phases of the acquisition cycle.
  - a large data-acquisition system
  - Lewis, R. O. 1992. *Independent Verification and Validation*. John Wiley & Sons Inc, Canada Lewis, pg 320

*Competency Level: Mastery*

- xviii) Hour eighteen: Given a case study, assess how differences between levels of abstraction support different the different phases of the acquisition cycle.
  - building valid, credible, and appropriately detailed simulation models
  - Law, A. M., D. W. Kelton. 2000 . *Simulation Modeling and Analysis*. The McGraw-Hill Companies, Inc., Boston, MA.

*Competency Level: Application*

- xix) Hour nineteen: Given a case study, assess how differences between levels of abstraction support different the different phases of the acquisition cycle.
  - building valid, credible, and appropriately detailed simulation models
  - Law, A. M., D. W. Kelton. 2000. *Simulation Modeling and Analysis*. The McGraw-Hill Companies, Inc., Boston, MA.

*Competency Level: Mastery*

- xx) Hour twenty: Given a case study, assess how differences between levels of abstraction support different the different phases of the acquisition cycle.
  - building valid, credible, and appropriately detailed simulation models
  - Law, A. M., D. W. Kelton. 2000. *Simulation Modeling and Analysis*. The McGraw-Hill Companies, Inc., Boston, MA.

*Competency Level: Mastery*

- xxi) Hour twenty one: Given a case study, evaluate the impact of different levels of abstraction on verification and validation.
  - abstraction of verification and validation
  - validation and verification
  - Greasley, A. 2004. *Simulation Modeling for Business*. Ashgate Publishing Limited, Burling, VT.

*Competency Level: Mastery*

- xxii) Hour twenty two: Given a case study, evaluate the impact of different levels of abstraction on verification and validation.
  - different levels of abstraction
  - validation and verification
- Greasley, A. 2004. *Simulation Modeling for Business*. Ashgate Publishing Limited, Burling, VT.

*Competency Level: Mastery*

- xxiii) Hour twenty three: Given a case study, evaluate the impact of different levels of abstraction on verification and validation.
  - different levels of abstraction
  - validation and verification
- Greasley, A. 2004. *Simulation Modeling for Business*. Ashgate Publishing Limited, Burling, VT.

*Competency Level: Mastery*

- xxiv) Hour twenty four: Given a case study, evaluate the impact of different levels of abstraction on verification and validation.
  - verification and validation
  - different levels of abstraction
  - validation and verification
- Greasley, A. 2004. *Simulation Modeling for Business*. Ashgate Publishing Limited, Burling, VT.

**O5) Identify appropriate M&S applications for each of the components of logistics systems, including Supply Chain, Storage systems, Facilities, Production, Inventory management, Transportation & distribution, Replenishment policies.**

- 1) Module name: Components of Logistics Systems
- 2) Module coordinator: Marsha Taliaferro-Gillis, Ph.D.  
6596 Main Street  
Gloucester, VA 23061  
(804)694-3173 (Office)  
(804)824-4663 (Cell)  
mtgillis@werneranderson.com
- 3) Module description: Identify appropriate M&S applications for each of the components of logistics systems, including Supply Chain, Storage systems, Facilities, Production, Inventory management, Transportation & distribution, Replenishment policies.
- 4) ESRs that the module supports: O5
- 5) Prerequisites assumed, and corresponding level of mastery:
- 6) Module maturity: none
- 7) Number of hours estimated to teach: 27
- 8) Proposed Delivery modality: face-to-face, on-line, VTC, resident, customer's site
- 9) Proposed references and texts:  
Brandimarte, Zotteri 2006. *Introduction to Distribution Logistics*, John Wiley and Sons Inc. Hoboken, New Jersey  
  
Hugos, M. 2006. *Essentials of Supply Chain Management*, 2nd Ed. John Wiley & Sons, Inc, Hoboken, NJ.  
  
Kress, M. 2002. *Operational Logistics: The Art and Science of Sustaining Military Operations*. Kluwer Academic Publishers, Norwell, MA.  
  
Rahim, M.A. 2001. *Integrated Models in Production Planning, Inventory, Quality, and Maintenance*, Kluwer Academic Publishers, Norwell, MA.  
  
Rushton, A., Croucher, P., Peter Baker. 2006. *The Handbook of Logistics and Distribution Management*, 3rd Ed. Bell & Bain, Glasgow, United Kingdom.

Stadtler, H., C. Kilger. 2005. *Supply Chain Management and Advanced Planning: Concepts, Models, Software and Case Studies*, Springer Berlin, Heidelberg, Germany.

The Defense Acquisition University Press, *Test and Evaluation Management Guide*, 5th Ed 2005. Fort Belvoir, VA.-

10) Module learning objectives:

- O5.1 Identify the methods and characteristics of different supply chain, et al modeling methods (e.g., discrete event simulation, constraint optimization, spreadsheet, network design, rough cut methods, discrete vs. stochastic).
- O5.2 Describe the advantages/disadvantages to different methods of different supply chain, et al modeling methods (discrete event simulation, constraint optimization, and spreadsheet).
- O5.3 Understand the role of constraints and the methods for capturing them in various modeling methodologies.
- O5.4 Understand the role of data in logistics modeling, the challenges in obtaining data, and the importance of sensitivity analysis of input data and of analysis drivers.
- O5.5 Understand how to integrate end-to-end logistics system modeling from production and the start of the supply chain to distribution and the setting of replenishment policies.
- O5.6 Given a case study, apply or analyze the methods used and the components considered in modeling a Supply Chain.
- O5.7 Given a case study, apply or analyze the methods used and the components considered in modeling a Storage System.
- O5.8 Given a case study, apply or analyze the methods used and the components considered in modeling a Production Facility.
- O5.9 Given a case study, apply or analyze the methods used and the components considered in modeling Inventory Management.
- O5.10 Give a case study, apply or analyze the methods used and the components considered in modeling a Distribution Network.
- O5.11 Given a case study, apply or analyze the methods used and the c components considered in modeling Replenishment Policies.

11) Course assessment plan: projects, and exams

12) Topic list by hour of instruction and reference.

*Competency Level: General Awareness*

- i) Hour 1: Identify the methods and characteristics of different supply chain, et al modeling methods (e.g., discrete event simulation, constraint optimization, spreadsheet, network design, rough cut methods, discrete vs. stochastic).
  - o supply chain management

- modeling strategic supply chain design
- Stadtler, H., C. Kilger. 2005 *Supply Chain Management and Advanced Planning: Concepts, Models, Software and Case Studies*, Springer Berlin, Heidelberg, Germany.

*Competency Level: General Awareness*

- ii) Hour 2: Describe the advantages/disadvantages to different methods of different supply chain, et al modeling methods (discrete event simulation, constraint optimization, and spreadsheet).
  - supply chain potential analysis
  - Stadtler, H., C. Kilger. 2005 *Supply Chain Management and Advanced Planning: Concepts, Models, Software and Case Studies*, Springer Berlin, Heidelberg, Germany.

*Competency Level: General Awareness*

- iii) Hour 3: Understand the role of constraints and the methods for capturing them in various modeling methodologies.
  - structure of production/distribution network
  - Brandimarte, Zotteri 2006 *Introduction to Distribution Logistics*, John Wiley and Sons Inc. Hoboken, New Jersey

*Competency Level: Understanding*

- iv) Hour 4: Understand the role of constraints and the methods for capturing them in various modeling methodologies.
  - structure of production/distribution network
  - Brandimarte, Zotteri 2006 *Introduction to Distribution Logistics*, John Wiley and Sons Inc. Hoboken, New Jersey

*Competency Level: General Awareness*

- v) Hour 5: Understand the role of data in logistics modeling, the challenges in obtaining data, and the importance of sensitivity analysis of input data and of analysis drivers.
  - planning logistics in an operation
  - Kress, M. 2002 *Operational Logistics: The Art and Science of Sustaining Military Operations*. Kluwer Academic Publishers, Norwell, MA.

*Competency Level: Understanding*

- vi) Hour 6: Understand the role of data in logistics modeling, the challenges in obtaining data, and the importance of sensitivity analysis of input data and of analysis drivers.
  - logistic responsiveness in operations
  - Kress, M. 2002 *Operational Logistics: The Art and Science of Sustaining Military Operations*. Kluwer Academic Publishers, Norwell, MA.

*Competency Level: General Awareness*

- vii) Hour 7: Understand how to integrate end-to-end logistics system modeling from production and the start of the supply chain to distribution and the setting of replenishment policies.
  - creating supply chains for competitive advantage
  - Hugos, M. 2006 *Essentials of Supply Chain Management*, 2nd Ed. John Wiley & Sons, Inc, Hoboken, NJ.

*Competency Level: Understanding*

- viii) Hour 8: Understand how to integrate end-to-end logistics system modeling from production and the start of the supply chain to distribution and the setting of replenishment policies.
  - infrastructure t&e
  - *The Defense Acquisition University Press, Test and Evaluation Management Guide*, 5th Edition.2005.Fort Belvoir, VA Logistics

*Competency Level: Understanding*

- ix) Hour 9: Understand how to integrate end-to-end logistics system modeling from production and the start of the supply chain to distribution and the setting of replenishment policies.
  - supply chain operations: planning and sourcing
  - Hugos, M. 2006 *Essentials of Supply Chain Management*, 2nd Ed. John Wiley & Sons, Inc, Hoboken, NJ.

*Competency Level: Application*

- x) Hour 10; Given a case study, apply or analyze the methods used and the components considered in modeling a Supply Chain.
  - types of supply chains
  - Stadtler, H., C. Kilger. 2005 *Supply Chain Management and Advanced Planning: Concepts, Models, Software and Case Studies*, Springer Berlin, Heidelberg, Germany

*Competency Level: Mastery*

- xi) Hour 11: Given a case study, apply or analyze the methods used and the components considered in modeling a Supply Chain.
  - integrated models for multi-storage systems
  - Rahim, M.A .,2001. *Integrated Models in Production Planning, Inventory, Quality, and Maintenance*, Kluwer Academic Publishers, Norwell, MA

*Competency Level: Mastery*

- xii) Hour 12: Given a case study, apply or analyze the methods used and the components considered in modeling a Supply Chain.
  - supply chain operations: planning and sourcing

- Hugos, M. 2006 *Essentials of Supply Chain Management*, 2nd Ed. John Wiley & Sons, Inc, Hoboken, NJ.

*Competency Level: Application*

- xiii) Hour 13: Given a case study, apply or analyze the methods used and the components considered in modeling a Storage System.
- supply chain operations: planning and sourcing
  - Hugos, M. 2006 *Essentials of Supply Chain Management*, 2nd Ed. John Wiley & Sons, Inc, Hoboken, NJ.

*Competency Level: Mastery*

- xiv) Hour 14: Given a case study, apply or analyze the methods used and the components considered in modeling a Storage System.
- supply chain operations: planning and sourcing
  - Hugos, M. 2006 *Essentials of Supply Chain Management*, 2nd Ed. John Wiley & Sons, Inc, Hoboken, NJ.

*Competency Level: Mastery*

- xv) Hour 15: Given a case study, apply or analyze the methods used and the components considered in modeling a Storage System.
- supply chain potential analysis
  - Stadtler, H., C. Kilger. 2005 *Supply Chain Management and Advanced Planning: Concepts, Models, Software and Case Studies*, Springer Berlin, Heidelberg, Germany.

*Competency Level: Application*

- xvi) Hour 16: Understand how to integrate end-to-end logistics system modeling from production and the start of the supply chain to distribution and the setting of replenishment policies.
- key issues and challenges for logistics
  - Rushton, A., Croucher, P., Peter Baker., 2006. *The Handbook of Logistics and Distribution Management*, 3rd Ed. Bell & Bain, Glasgow, United Kingdom.

*Competency Level: Mastery*

- xvii) Hour 17: Understand how to integrate end-to-end logistics system modeling from production and the start of the supply chain to distribution and the setting of replenishment policies.
- supply chain potential analysis
  - Stadtler, H., C. Kilger. 2005 *Supply Chain Management and Advanced Planning: Concepts, Models, Software and Case Studies*, Springer Berlin, Heidelberg, Germany.

*Competency Level: Mastery*

- xviii) Hour 18: Understand how to integrate end-to-end logistics system modeling from production and the start of the supply chain to distribution and the setting of replenishment policies.
- logistics management and organization
  - Rushton, A., Croucher, P., Peter Baker., 2006. *The Handbook of Logistics and Distribution Management*, 3rd Ed. Bell & Bain, Glasgow, United Kingdom.

*Competency Level: Application*

- xix) Hour 19: Given a case study, apply or analyze the methods used and the components considered in modeling Inventory Management.
- planning framework for logistics
  - Rushton, A., Croucher, P., Peter Baker., 2006. *The Handbook of Logistics and Distribution Management*, 3rd Ed. Bell & Bain, Glasgow, United Kingdom.

*Competency Level: Mastery*

- xx) Hour 20: Given a case study, apply or analyze the methods used and the components considered in modeling Inventory Management.
- inventory and the supply chain
  - Rushton, A., Croucher, P., Peter Baker., 2006. *The Handbook of Logistics and Distribution Management*, 3rd Ed. Bell & Bain, Glasgow, United Kingdom.

*Competency Level: Application*

- xxi) Hour 21: Given a case study, apply or analyze the methods used and the components considered in modeling Inventory Management.
- types of supply chains
  - Stadtler, H., C. Kilger. 2005 *Supply Chain Management and Advanced Planning: Concepts, Models, Software and Case Studies*, Springer Berlin, Heidelberg, Germany

*Competency Level: Mastery*

- xxii) Hour 22: Give a case study, apply or analyze the methods used and the components considered in modeling a Distribution Network.
- structure of production/distribution network
  - Brandimarte, Zotteri 2006 *Introduction to Distribution Logistics*, John Wiley and Sons Inc. Hoboken, New Jersey

*Competency Level: Mastery*

- xxiii) Hour 23: Give a case study, apply or analyze the methods used and the components considered in modeling a Distribution Network.
- models involving nonlinear cost for a distribution network



- Brandimarte, Zotteri 2006 *Introduction to Distribution Logistics*, John Wiley and Sons Inc. Hoboken, New Jersey

*Competency Level: Mastery*

- xxiv) Hour 24: Give a case study, apply or analyze the methods used and the components considered in modeling a Distribution Network.
  - the role of intermediate nodes in a distribution network
- . Brandimarte, Zotteri 2006 *Introduction to Distribution Logistics*, John Wiley and Sons Inc. Hoboken, New Jersey

*Competency Level: Application*

- xxv) Hour 25: Given a case study, apply or analyze the methods used and the components considered in modeling Replenishment Policies.
  - a Generalized integrated economic model for inventory and quality control programs
- Rahim, M.A., 2001 *Integrated Models in Production Planning, Inventory, Quality, and Maintenance*, Kluwer Academic Publishers, Norwell, MA.

*Competency Level: Mastery*

- xxvi) Hour 26: Given a case study, apply or analyze the methods used and the components considered in modeling Replenishment Policies.
  - an integrated model for inventory and quality controls
- Rahim, M.A., 2001. *Integrated Models in Production Planning, Inventory, Quality, and Maintenance*, Kluwer Academic Publishers, Norwell, MA

*Competency Level: Mastery*

- xxvii) Hour 27 Given a case study, apply or analyze the methods used and the components considered in modeling Replenishment Policies.
  - a single period inventory model to account for demand surprises
- Rahim, M.A., 2001 *Integrated Models in Production Planning, Inventory, Quality, and Maintenance*, Kluwer Academic Publishers, Norwell, MA.

**E1) Structural Mechanics, Shock and Vibrations**

**Describe basic structural mechanics including stress-strain relations, buckling and fatigue, shock and vibration, and finite element methods in M&S.**

*Course Name:* Structural Mechanics, Shock and Vibration

*Course coordinator:*

Matt Lear, PhD

MS 25-262

11100 Johns Hopkins Rd.

Laurel, MD 20723

*Course description:*

Describe the fundamentals of thermodynamics and heat transfer with applications to modeling and simulation in engineering power cycles, propulsion and auxiliary system cycle analysis and design.

*Modules incorporated into Course:* E1

ESRs that the course supports and corresponding level of mastery

- 1 Key fundamental theoretical principles in structural engineering

*Competency Level:* General Awareness

- 2 Role and benefits of M&S in structural engineering, particularly Finite Element Analysis

*Competency Level:* General Awareness

- 3 Key elements of the system and component subsystem to be modeled to meet the requirements of the specific use

*Competency Level:* Understanding

- 4 Effectiveness of simulation tools used to evaluate the performance of the system and components subsystems

*Competency Level:* Understanding

*Prerequisites assumed, and corresponding level of mastery:* Understanding of college-level chemistry and physics.

*Course maturity:* None

*Number of contact hours and pace contemplated:*

- One 8 classroom hour short course OR

Proposed delivery methods:

- Face-to-face or on-line

*Module learning objectives:*

- E1.1 Basic concepts of structural mechanics and the uses of Finite Element Analysis
- E1.2 Overview of element formulations and pitfalls
- E1.3 Modeling errors and accuracy
- E1.4 Computational techniques to solve common engineering problems and appropriateness
- E1.5 Limitations of finite elements and other methods

*Course learning objectives:*

Understanding thermal aspects of military systems and how M&S is employed as a part of system verification, validation and test.

- This includes an understanding of the basic fundamentals of finite element analysis as a tool to assess system structures.
- Mastery to be demonstrated by a satisfactory score on unit quizzes and final project.

## Course assessment plan:

- Satisfactory completion of course workbook and project material

## Topic list by hour of instruction and reference:

Session	Time	CL	Subject Area
1	1 Hour	GA	Basic concepts of structural mechanics and Finite Element Analysis <ul style="list-style-type: none"> <li>• Finite Element Method</li> </ul>
2	1 Hour	GA	Overview of finite element formulations <ul style="list-style-type: none"> <li>• Capabilities and pitfalls</li> </ul>
3	2 Hours	U	Finite element modeling <ul style="list-style-type: none"> <li>• Commonly used applications and tools</li> <li>• Model accuracy and errors</li> </ul>
4	3 Hours	U	Computational techniques to solve common engineering problems and appropriateness <ul style="list-style-type: none"> <li>• Structural elasticity</li> <li>• Applications in aerospace, civil and mechanical engineering</li> <li>• Other industrial applications</li> </ul>
5	1 Hour	U	Limitations of finite elements and other methods

## Competency Levels:

GA = General Awareness

U = Understanding

A = Application

M = Mastery

## **E2) Fluid Dynamics and Weapon System**

**Describe the basics of computational fluid dynamics for CFD application and use for M&S. Fluid dynamics of subsonic and supersonic weapons, warheads and their effects.**

*Course Name:* Fluid Dynamics and Weapon Systems

*Course coordinator:*

Dr. Bo Cybyk and Dr. Ashish Nedungadi

MS 25-219

11100 Johns Hopkins Rd.

Laurel, MD 20723

*Course description:*

Describe the fundamentals of computational fluid dynamics (CFD) with applications to modeling and simulation and Fluid dynamics of subsonic and supersonic weapons, warheads and their effects.

*Modules incorporated into Course:* E2

ESRs that the course supports and corresponding level of mastery

1. Philosophy of CFD and its role in the triad of experimental, theoretical, and numerical approaches
2. Basic governing equations for fluid dynamics, including inviscid and viscous forms suitable for CFD
3. Classes and behavior of partial differential equations; finite difference and finite volume formulations; and stability and convergence
4. Grid generation and the primary types (structured, unstructured, overset, etc.)
5. Basic CFD techniques for incompressible and compressible flows
6. Solutions of the Euler, Boundary Layer, Parabolized Navier-Stokes, and full Navier-Stokes equations in the context of subsonic and supersonic weapon applications
7. Modeling of turbulent flows, unsteady flows, and high-temperature flows in the context of subsonic and supersonic weapon applications
8. Flow visualization and data analysis techniques

9. Validation and verification methodologies using experimental, theoretical, and numerical data

10. Future of CFD in research and engineering

*Prerequisites assumed, and corresponding level of mastery:*

Understanding of college-level physics and mathematics. A basic understanding of partial differential equations would be desired.

*Course maturity:* None

*Number of contact hours and pace contemplated:*

- 10 three-four classroom hour sessions OR
- One 32 classroom hour short course OR
- This could also be broken up into two short courses
  - o Basic course consisting of modules E2.1 through E2.5. (16 classroom hours)
  - o Advanced numerical methods course would follow-on to the basic course. This would include E2.6 through E2.10 (16 classroom hours).

*Proposed delivery methods:*

- Face-to-face or on-line

*Course objectives:*

Understanding the various aspects of computational fluid dynamics and the proper use of CFD for military systems and how M&S is employed as a part of system verification, validation and test.

- This includes an understanding of the basic fundamentals of governing equations of fluid motion.
- Students will review how fluid dynamics affect military systems in tactical operations.
- Students will learn the basic steps involved in going from a CAD geometry model to final analysis of the CFD solution for applications that are relevant for military systems.
- Students will learn how to construct a good CFD models (including grids, initial conditions, and boundary conditions) for numerical analysis and how to minimize potential sources of error.
- Mastery to be demonstrated by a satisfactory score on unit quizzes and final project.

*Course assessment plan:*

- Satisfactory completion of course workbook and project material

Topic list by hour of instruction and reference:

ESR #	ESR Description	
E2	Fluid Dynamics and Weapon Systems - Understand the basics of computational fluid dynamics for CFD application and use for M&S. Fluid dynamics of subsonic and supersonic weapons, warheads and their effects.	
E2.1	Philosophy of CFD and its role in the triad of experimental, theoretical, and numerical approaches	2 hr
E2.2	Basic governing equations for fluid dynamics, including inviscid and viscous forms suitable for CFD	4 hr
E2.3	Classes and behavior of partial differential equations; finite difference and finite volume formulations; and stability and convergence	2 hr
E2.4	Grid generation and the primary types (structured, unstructured, overset, etc.)	4 hr
E2.5	Basic CFD techniques for incompressible and compressible flows	4 hr
E2.6	Solutions of the Euler, Boundary Layer, Parabolized Navier-Stokes, and full Navier-Stokes equations in the context of subsonic and supersonic weapon applications	2 hr
E2.7	Modeling of turbulent flows, unsteady flows, and high-temperature flows in the context of subsonic and supersonic weapon applications	4 hr
E2.8	Flow visualization and data analysis techniques	4 hr
E2.9	Validation and verification methodologies using experimental, theoretical, and numerical data	4 hr
E2.10	Future of CFD in research and engineering	2 hr

## Competency Levels:

GA = General Awareness

U = Understanding

A = Application

M = Mastery

### **E3) Dynamics and Control**

**Describe the basics of M&S in process and multi-physics (mechanical, electrical & hydraulic) based dynamic system controls.**

*Course Name:* Guidance, Navigation, and Control

*Course coordinator:*

Wayne Elliott

MS 24-E288

11100 Johns Hopkins Rd.

Laurel, MD 20723

*Course description:*

Describe the basic principles of guidance, navigation and control used in military systems that apply modeling and simulation as part of system verification, validation, test and evaluation.

*Modules incorporated into Course:* E3

*ESRs that the course supports and corresponding level of mastery*

- 1 Key fundamental theoretical principles in systems engineering  
*Competency Level: General Awareness*
- 2 Role and benefits of M&S in systems engineering  
*Competency Level: General Awareness*
- 3 Key system characteristics of the system and component subsystems of interest  
*Competency Level: General Awareness*
- 4 Key elements of the system and component subsystem to be modeled to meet the requirements of the specific use  
*Competency Level: General Awareness*
- 5 Effectiveness of simulation tools used to evaluate the performance of the system and components subsystems  
*Competency Level: Application*
- 6 Role of component-based and distributed simulation as it applies to the system and component subsystems  
*Competency Level: Application*
- 7 M&S issues related to interaction of subsystems within a larger system  
*Competency Level: Application*



- 8 VV&A implication of using a simulation of a system that is sufficiently different from its intended use

*Competency Level: Application*

- 9 Level of model detail for system and component subsystems to support program milestone decision requirements

*Competency Level: Mastery*

- 10 Level of model detail for system and component subsystems to support T&E requirements

*Competency Level: Mastery*

*Prerequisites assumed, and corresponding level of mastery: None*

*Course maturity: None*

*Number of contact hours and pace contemplated:*

One 38 hour short course

This course could also be broken into two short courses.

- Basic course E3.1, E3.5, E3.8, E3.9 (18 classroom hours)
- Advanced course would include all modules.

*Proposed delivery methods:*

- Face-to-face or on-line

*Module learning objectives:*

- E3.1 Provide a basic introduction of guidance, navigation and control as they apply to military applications.
- E3.2 Provide an introduction of the types and usage of modeling and simulation for military systems that use guidance, control and navigation (Prerequisite: E3.1 or equivalent knowledge)
- E3.3 Identify the use of M&S tools to simulate guidance, navigation and control applications. (Prerequisite: E3.1 or appropriate knowledge)
- E3.4 Introduce the application of hardware in the loop simulation for guidance, navigation and control systems.
- E3.5 Introduce the uses of M&S to evaluate guidance, navigation and control systems.
- E3.6 Introduction to using M&S to predict performance.
- E3.7 Introduction to M&S, VV&A as it applied to guidance, navigation and control

E3.8 Present the uses of M&S in guidance, navigation and control systems to support program decisions.

E3.9 Present the uses of M&S for guidance, navigation and control to support T&E requirements.

*Course learning objectives:*

Understanding of guidance, navigation and control and how M&S is employed as a part of acquisition, system verification, validation, accreditation and test.

- This includes a basic understanding of the fundamentals of guidance, navigation and control.
- Students will review types of models and simulations and their appropriate usage.
- Students will also gain insight into hardware in the loop simulation and limitations of various simulation techniques.
- Mastery to be demonstrated by a satisfactory score on unit quizzes and final project.

*Course assessment plan:*

- Satisfactory completion of course workbook and project material

Topic list by hour of instruction and reference:

Session	Time	CL	Subject Area
1	10 Hours	GA	Fundamentals of guidance, navigation and control Topics include: <ul style="list-style-type: none"> <li>• Tactical Guidance and Navigation               <ul style="list-style-type: none"> <li>○ Proportional Navigation</li> <li>○ Equations for Modeling</li> <li>○ Sample Applications</li> <li>○ Zero Effort Miss</li> <li>○ Alternate Tactical Guidance Schemes</li> <li>○ Implementation Issues and M&amp;S</li> </ul> </li> <li>• Strategic Guidance and Navigation               <ul style="list-style-type: none"> <li>○ Lambert Guidance</li> <li>○ Equations of Motion</li> <li>○ Gravitational Model</li> <li>○ Coordinate Systems</li> </ul> </li> </ul>
2	4 Hours	GA	Types and usage of M&S for guidance, navigation and control. Topics include: <ul style="list-style-type: none"> <li>• Introduction of inertial instruments               <ul style="list-style-type: none"> <li>○ Accelerometers, rate gyros, stellar monitors, strapdown systems, IMU, GPS</li> <li>○ Introduction to guidance, navigation and control error sources and models</li> </ul> </li> <li>• Model fidelity</li> <li>• Simulation structures</li> </ul>

3	4 Hours	U	Identify the use of M&S tools to simulate guidance, navigation and control. This includes: <ul style="list-style-type: none"> <li>• Whole value verses error modeling.</li> <li>• Multiple degree of freedom simulation 3D-6D</li> <li>• Equations of motion</li> <li>• Environmental models</li> </ul>
4	4 Hours	U	Introduce the application of hardware in the loop simulation for guidance, navigation and control systems. Review the associated hardware elements used in HWIL.
5	4 Hours	U	Introduce the uses of M&S to evaluate guidance, navigation and control systems. This includes: <ul style="list-style-type: none"> <li>• Single instance characteristics</li> <li>• Monte Carlo techniques</li> <li>• Modeling errors in Kalman Filters</li> <li>• Limitations of evaluation using M&amp;S</li> </ul>
6	4 Hours	A	Introduction to using M&S in conjunction with error models to predict performance in untested regimes. Topics include: <ul style="list-style-type: none"> <li>• Necessary detail of underlying models</li> <li>• Model propagation techniques</li> <li>• Sensitivity matrices, error partials</li> <li>• Limitations of predictive capability</li> </ul>
7	4 Hours	A	Introduction of M&S VV&A as it applied to guidance, navigation and control. <ul style="list-style-type: none"> <li>• Necessity of accredited simulations</li> <li>• Differences between validation and accreditation</li> <li>• Organizations responsible for components of VV&amp;A</li> </ul>
8	2 Hours	M	Present the uses of M&S in systems engineering of military systems and guidance, navigation and control systems in order to support program decisions. This includes cost, schedule and effectiveness of M&S in predicting performance.
9	2 Hours	M	Present the uses of M&S for guidance, navigation and control to support T&E requirements including establishing test cases, test sizing, test instrumentation, facility, equipment and personnel planning.

## Competency Levels:

GA = General Awareness

U = Understanding

A = Application

M = Mastery

1 Proposed references and texts:

TBS

**E4) Thermodynamics and Heat Transfer**

**Describe the fundamentals of thermodynamics and heat transfer with applications to M&S in engineering power cycles, propulsion and auxiliary system cycle analysis and design.**

*Course Name:* Thermodynamics and Heat Transfer

Course coordinator:  
Don King, PE  
MS 25-217  
11100 Johns Hopkins Rd.  
Laurel, MD 20723

*Course description:*

Describe the fundamentals of thermodynamics and heat transfer with applications to modeling and simulation in engineering power cycles, propulsion and auxiliary system cycle analysis and design.

*Modules incorporated into Course:* E4

ESRs that the course supports and corresponding level of mastery

- 1 Governing equations of mass, momentum, energy conservation (1st Law and 2nd Law) and heat transfer (conduction, convection, and radiation).

*Competency Level:*

- 2 Physical properties and constitutive relationships

*Competency Level:*

- 3 Thermodynamic cycles

*Competency Level:*

- 4 Combustion and chemical reactions

*Competency Level:*

- 5 Power cycle applications: steam power cycle, refrigeration, heat pumps, turbines, rockets and jets, and internal combustion engines

*Competency Level:*

- 6 Heat transfer applications: Aerodynamic heating, IR signature, satellite heating and cooling, engine cooling, electronics cooling, HVAC, solar heating, phase change

*Competency Level:*

- 7 Numerical solution techniques such as finite difference, finite volume, and finite element

*Competency Level:*

- 8 Application and limitations of finite element method to heat transfer problems

*Competency Level:*

- 9 Chemical reaction and combustion numerical methods

*Competency Level:*

- 10 Other simulation methods

*Competency Level:**Prerequisites assumed, and corresponding level of mastery:*

Understanding of college-level chemistry and physics.

*Course maturity:* None

*Number of contact hours and pace contemplated:*

- 14 three classroom hour sessions OR
- One 40 classroom hour short course OR
- This could also be broken up into two short courses
  - o Basic course consisting of modules E4.1 through E4.6. (25 classroom hours)
  - o Advanced numerical methods course would follow-on to the basic course. This would include E4.7 through E4.10 (15 classroom hours).

*Proposed delivery methods:*

- Face-to-face or on-line

*Module learning objectives:*

- E4.1 Provide a basic introduction of thermodynamics and heat transfer fundamentals and their application to the M&S of military systems.
- E4.2 Provide a fundamental understanding of material properties of interest and their use in solving thermodynamic and heat transfer problems. (Prerequisite: E4.1 or appropriate knowledge).
- E4.3 Introduce useful thermodynamic cycles and analysis approach to each and interpretation of results. (Prerequisite: E4.2 or appropriate knowledge).
- E4.4 Identify chemical reactions (including combustion-based, non-combustion, and explosive reactions) of military interest. Provide understanding of analysis approach and interpretation of results. (Prerequisite: E4.3 or appropriate knowledge).

- E4.5 Building on previous modules (E.4.1 to E4.4), solve example M&S problems focused on military applications of power cycles. (Prerequisite: E4.4 or appropriate knowledge)
- E4.6 Building on previous modules (E.4.1 to E4.4), solve example M&S problems involving heat transfer in military systems. (Prerequisite: E4.4 or appropriate knowledge)
- E4.7 Introduce a wide-range of numerical techniques and tools for solving thermodynamic and heat-transfer problems via M&S. (Prerequisite: E 4.5 and E4.6 or appropriate knowledge).
- E4.8 Apply M&S numerical methods to solve heat transfer problems using examples from military systems. (Prerequisite: E4.7 or appropriate knowledge).
- E4.9 Apply M&S numerical methods to solving combustion and chemical reaction problems using examples from military systems. (Prerequisite: E4.7 or appropriate knowledge).
- E4.10 Discuss other relevant M&S methods and techniques. (Prerequisite: E4.7 or appropriate knowledge).

*Course learning objectives:*

Understanding thermal aspects of military systems and how M&S is employed as a part of system verification, validation and test.

- This includes an understanding of the basic fundamentals of thermodynamics and heat transfer.
- Students will review how thermal issues affect use of military systems in tactical operations.
- Students will learn how to construct a good model for M&S numerical analysis and how to minimize potential sources of error.
- Mastery to be demonstrated by a satisfactory score on unit quizzes and final project.

*Course assessment plan:*

- Satisfactory completion of course workbook and project material

Topic list by hour of instruction and reference:

Session	Time	CL	Subject Area
1	3 Hours		Overview and fundamentals of thermodynamics and heat transfer in M&S. Topics include: <ul style="list-style-type: none"> <li>• Military applications</li> <li>• Control volumes</li> <li>• Conservation of mass and energy</li> <li>• Entropy</li> <li>• Heat transfer modes</li> </ul>
2	2 Hours		Material properties necessary for heat transfer and thermodynamic calculations. Topics include:

			<ul style="list-style-type: none"> <li>• Intrinsic vs. extrinsic properties</li> <li>• Thermodynamic properties</li> <li>• Heat transfer properties</li> </ul>
3	3 Hours		Thermodynamic cycles. This includes: <ul style="list-style-type: none"> <li>• Heat engine cycles</li> <li>• Refrigeration cycles</li> <li>• Combustion and compression</li> <li>• Heat exchangers</li> </ul>
4	3 Hours		Combustion and chemical reactions. Topics include: <ul style="list-style-type: none"> <li>• Combustion</li> <li>• Explosive reactions</li> <li>• Non-combustion chemical reactions</li> </ul>
5	6 Hours		Discuss M&S of various cycles encountered in military systems. Topics to include: <ul style="list-style-type: none"> <li>• Power generation cycles</li> <li>• Refrigeration and heat pumps</li> <li>• Engine cycles (rocket, jet, and internal combustion)</li> </ul>
6	8 Hours		Discuss M&S of various military heat transfer problems. Example problems to include: <ul style="list-style-type: none"> <li>• Electronics cooling</li> <li>• Aerodynamic heating</li> <li>• IR signature of vehicles</li> <li>• Satellite heating and cooling</li> <li>• Engine cooling</li> <li>• HVAC</li> <li>• Solar heating</li> <li>• Phase change</li> </ul>
7	3 Hours		Introduce M&S numerical methods and modeling tools. Lay foundation for following sessions.
8	9 Hours		Discuss application and limitations of using finite element method to solve heat transfer problems. Discuss appropriate model construction level of detail and approach. Discuss sensitivity and error analysis methods. Example problems to include: <ul style="list-style-type: none"> <li>• Electronics cooling</li> <li>• Aerodynamic heating</li> <li>• IR signature of vehicles</li> <li>• Satellite heating and cooling</li> </ul>
9	1.5 Hours		Discuss M&S numerical methods to solve chemical reaction and combustion problems. Example problems to include: <ul style="list-style-type: none"> <li>• Propellant chemistry</li> <li>• Rocket exhaust IR analysis</li> </ul>
10	1.5 Hours		Introduce other M&S methods (primarily empirical).

Competency Levels:

GA = General Awareness

U = Understanding

A = Application

M = Mastery



**E5) Materials and Fabrication**

**Describe the basic materials technology associated with manufacturing, welding and corrosion control. Have an introduction to composite, superconducting materials, and fiber optics as applied to M&S.**

*Course Name:* Materials and Fabrication

*Course coordinators:*

Andrew M. Lennon

Michael Rooney

MS 13-N209

David Drewry

MS 25-N217

11100 Johns Hopkins Rd.

Laurel, MD 20723

*Course description:*

Describe the basic materials technology associated with manufacturing, welding and corrosion control. Have an introduction to composite, superconducting materials, and fiber optics as applied to M&S.

*Modules incorporated into Course:* E5

*ESRs that the course supports and corresponding level of mastery*

- 1 Key fundamental theoretical principles in materials science  
*Competency Level:* General Awareness
- 2 Role and benefits of M&S in materials science  
*Competency Level:* Application
- 3 Key characteristics of engineering materials of interest  
*Competency Level:* Understanding
- 4 Key characteristics of materials to be modeled to meet the requirements of the specific use  
*Competency Level:* Understanding
- 5 Effectiveness of simulation tools used to evaluate the performance of materials for the specific use  
*Competency Level:* Application
- 6 M&S issues related to interaction of materials within a larger system

*Competency Level:*        *Application*

- 7    Level of model detail for material testing to support program milestone decision requirements

*Competency Level:*        *Application*

- 8    Level of model detail for materials testing to support T&E requirements

*Competency Level:*        *Application*

*Prerequisites assumed, and corresponding level of mastery:* None

*Course maturity:*    None

*Number of contact hours and pace contemplated:*

- 14 three classroom hour sessions OR
- One 40 classroom hour short course

*Proposed delivery methods:*

- Face-to-face or on-line

*Module learning objectives:*

- E5.1    Provide a basic introduction and review of materials science, including discussion of stress/strain definitions and relationship and the different classes/types of materials and their uses. More detailed discussion of governing equations are covered in ESR E1.1.
- E5.2    Discuss the fundamental behavior of metals, their methods of manufacture and the effect of fabrication parameters and other factors (e.g., strain rate, temperature) on their final properties. Discussions to include heat treatment, strain hardening and corrosion.
- E5.3    Discuss the fundamental behavior of ceramics and glasses, their methods of manufacture and the effect of fabrication parameters and other factors on final properties.
- E5.4    Discuss the fundamental behavior of polymeric materials, their methods of manufacture and the effect of fabrication parameters and environmental factors on final properties.
- E5.5    Discuss the fundamental behavior of composite materials, their methods of manufacture and the effect of fabrication and other parameters on final properties.

- E5.6 Discuss the manufacture and behavior of novel materials such as superconductors, fiber optics, etc.
- E5.7 Provide a basic understanding of material joining techniques (i.e., welding, adhesive bonding, bolted joints) and methods of estimating/ measuring their impact on interfacial and overall properties.
- E5.8 Provide a general overview of testing methods for determining the various material properties used in M&S, including both quasi-static and dynamic/high-rate methods. Discussions will also be presented on detection and quantification of manufacturing and/or material defects and their impact on M&S, which will include an overview of NDE methods.
- E5.9 Discuss general classes of material coatings and their applications, such as corrosion and wear prevention.

*Course learning objectives:*

Develop an understanding of materials science fundamentals relevant to materials selection for specific applications.

- Become familiar with different classes of engineering materials and their trade-offs associated with strength, toughness, corrosion-resistance, fabricability and cost.
- Learn M&S techniques for coupon-level evaluation materials properties.
- Gain an awareness of fabrication and joining techniques for different materials classes, as well as coatings for enhancing properties of the materials system.
- Demonstrate mastery of course objectives through unit quizzes and final examination.

*Course assessment plan:*

- Satisfactory completion of course workbook and project material

Topic list by hour of instruction and range of competency levels:

Session	Time	CL	Subject Area
1	4 Hours	GA	Introduction to materials science fundamentals <ul style="list-style-type: none"> <li>• Definition of material stress and strain</li> <li>• Stress/strain relationships               <ul style="list-style-type: none"> <li>○ Modulus</li> <li>○ Yield point</li> <li>○ Toughness (strain energy)</li> <li>○ Ductility (elongation to break)</li> </ul> </li> <li>• Multiaxial stress states               <ul style="list-style-type: none"> <li>○ Hydrostatic pressure</li> <li>○ Biaxial tension</li> <li>○ Tension-torsion</li> <li>○ Deviatoric stress decomposition</li> </ul> </li> <li>• Material Anisotropy</li> <li>• Classes of engineering materials</li> </ul>

			<ul style="list-style-type: none"> <li>○ Metals</li> <li>○ Ceramics and glasses</li> <li>○ Polymeric materials</li> <li>○ Composites <ul style="list-style-type: none"> <li>▪ Fiber reinforced composites</li> <li>▪ Particle reinforced composites</li> </ul> </li> <li>○ Specialty materials <ul style="list-style-type: none"> <li>▪ Fiber optics</li> <li>▪ Superconducting materials</li> </ul> </li> </ul>
2	6 Hours	GA thru U	<p>Behavior of engineering metals</p> <ul style="list-style-type: none"> <li>● Work hardening</li> <li>● Heat treatment</li> <li>● Characteristics of Common Engineering Metals <ul style="list-style-type: none"> <li>○ Common steels</li> <li>○ Alloy steels</li> <li>○ Stainless steels</li> <li>○ Non-Ferrous alloys <ul style="list-style-type: none"> <li>– Aluminum alloys</li> <li>– Copper alloys</li> <li>– Nickel alloys</li> <li>– Magnesium alloys</li> <li>– Specialty alloys</li> </ul> </li> </ul> </li> <li>● Corrosion <ul style="list-style-type: none"> <li>○ Galvanic corrosion</li> <li>○ Pitting corrosion</li> <li>○ Stress corrosion cracking</li> <li>○ High temperature oxidation</li> </ul> </li> <li>● Creep</li> <li>● Fabrication methods <ul style="list-style-type: none"> <li>○ Casting</li> <li>○ Extrusion, rolling and forging</li> <li>○ Machining (milling, turning, grinding, EDM)</li> <li>○ Powder metallurgy</li> </ul> </li> </ul>
3	2 Hours	GA thru U	<p>Behavior of engineering ceramics and glasses</p> <ul style="list-style-type: none"> <li>● Brittle fracture</li> <li>● Griffith fracture criterion <ul style="list-style-type: none"> <li>○ Flaw-dominated strength</li> <li>○ Cracking modes</li> <li>○ Fracture toughness</li> </ul> </li> <li>● Fabrication techniques <ul style="list-style-type: none"> <li>○ Casting</li> <li>○ Sintering</li> <li>○ Grinding</li> </ul> </li> </ul>
4	3 Hours	GA thru U	<p>Behavior of engineering polymers</p> <ul style="list-style-type: none"> <li>● Viscoelasticity and the complex modulus</li> <li>● Stress relaxation and creep</li> </ul>

			<ul style="list-style-type: none"> <li>• Glass transition</li> <li>• Thermal breakdown</li> <li>• Common polymeric materials               <ul style="list-style-type: none"> <li>○ Thermosets (e.g. bakelite)</li> <li>○ Thermoplastics (e.g. polycarbonate)</li> </ul> </li> <li>• Fabrication techniques               <ul style="list-style-type: none"> <li>○ Injection molding</li> <li>○ Casting</li> <li>○ Extrusion</li> </ul> </li> </ul>
5	4 Hours	GA thru U	Behavior of engineering composite materials <ul style="list-style-type: none"> <li>• Resin matrix composites               <ul style="list-style-type: none"> <li>○ Epoxies</li> <li>○ Cyanate and Vinyl esters</li> <li>○ Polyurethane</li> </ul> </li> <li>• Fiber Reinforcements               <ul style="list-style-type: none"> <li>○ Fibers, tows and fabrics</li> <li>○ E- and S-glass</li> <li>○ Carbon</li> </ul> </li> <li>• Metal and Ceramic matrix composites</li> <li>• Frabrication Techniques               <ul style="list-style-type: none"> <li>○ VARTM</li> <li>○ Press molding</li> <li>○ Prepreg/Autoclave</li> <li>○ Filament Winding</li> <li>○ Pultrusion</li> </ul> </li> </ul>
6	2 Hours	GA thru U	Properties of novel materials <ul style="list-style-type: none"> <li>• Superconducting materials               <ul style="list-style-type: none"> <li>○ Mechanical properties</li> <li>○ Thermal properties</li> <li>○ Fabrication process</li> </ul> </li> <li>• Optical fibers               <ul style="list-style-type: none"> <li>○ Mechanical properties</li> <li>○ Fabrication processes</li> <li>○ Joining processes</li> </ul> </li> </ul>
7	4 Hours	GA thru A	Material joining techniques <ul style="list-style-type: none"> <li>• Welding               <ul style="list-style-type: none"> <li>○ Filler material selection</li> <li>○ Heat affected zone</li> <li>○ Corrosion considerations</li> </ul> </li> <li>• Fasteners               <ul style="list-style-type: none"> <li>○ Torque specification</li> <li>○ Shear properties (bolt-shear, thread shear, substrate shear-out)</li> <li>○ Corrosion considerations</li> </ul> </li> <li>• Adhesive bonding</li> </ul>

8	10 Hours	GA thru A	<p>Modeling and Simulation</p> <ul style="list-style-type: none"> <li>• Mechanical test methods <ul style="list-style-type: none"> <li>○ Load frames <ul style="list-style-type: none"> <li>▪ Tension, compression, shear</li> <li>▪ Bend testing</li> <li>▪ Peel testing</li> <li>▪ Load vs. deflection of structures</li> </ul> </li> <li>○ Hardness Testing</li> <li>○ Wear testing</li> </ul> </li> <li>• Thermal analysis <ul style="list-style-type: none"> <li>○ DMA – Dynamic Mechanical Analysis</li> <li>○ (M)DSC – (Modulated) Differential Scanning Calorimetry</li> <li>○ TGA – Thermogravimetric analysis</li> <li>○ Flash diffusivity/thermal conductivity</li> <li>○ Accelerated life testing</li> </ul> </li> <li>• High rate testing <ul style="list-style-type: none"> <li>○ Charpy impact testing</li> <li>○ Drop towers</li> <li>○ Kolsky bar (split-Hopkinson pressure bar)</li> </ul> </li> <li>• Corrosion Testing <ul style="list-style-type: none"> <li>○ Stress-corrosion cracking methods</li> <li>○ Salt spray exposure</li> <li>○ Immersion methods</li> <li>○ High temperature exposure standards</li> </ul> </li> <li>• Non-Destructive Evaluation (NDE) <ul style="list-style-type: none"> <li>○ Dye penetration</li> <li>○ Magnetic particle</li> <li>○ Radiographic inspection</li> <li>○ Ultrasonic inspection</li> <li>○ Eddy current inspection</li> <li>○ Thermography</li> <li>○ Shearography</li> </ul> </li> </ul>
9	3 Hours	GA thru U	<p>Coatings</p> <ul style="list-style-type: none"> <li>• Paints</li> <li>• Powder coatings</li> <li>• Platings</li> <li>• Conversion coatings</li> <li>• Nitriding and carburization</li> <li>• Thermal/plasma spray coatings</li> <li>• Sputtered or vacuum deposited coatings</li> </ul>

Competency Levels:

GA = General Awareness

U = Understanding

A = Application

M = Mastery

**E6) Acoustic and Electromagnetic Systems**

**Describe the fundamentals of acoustic and electromagnetic wave propagation in M&S applications.**

- 1) Module name: Fundamentals of acoustic and electromagnetic systems
- 2) Module coordinator/POC: Anthony Genna  
UCSD Extension  
Assistant Director,  
Defense Technology  
agenna@ucsd.edu  
858-603-2170 (cell)
- 3) Module description: Develop appropriate M&S skills related to the fundamentals of acoustic and electromagnetic wave propagation and their application to DoD systems.
- 4) ESRs that the module supports and the corresponding level of mastery: E6
- 5) Prerequisites assumed, and corresponding level of mastery: (i.e., BS/MS degree or DAU/DoD courses, certifications, etc.) meeting requirements of current position and/or rank/grade/rate. DAU/DoD courses equivalent to the content of the text books listed below:
  - a) Urick, Principles of Underwater Sound 3rd Edition
  - b) Merrill Ivan Skolnik, "Radar is an electromagnetic system for the detection and location of reflecting objects such as aircraft, ships, spacecraft, vehicles, people, and the natural environment"

In addition it is recommended that student have academic training or OJT equivalent to the following levels of competency:

:

- (1) M&S "GA" module: General Awareness in current job position
  - (2) M&S "UN" module: Understanding in current job position
  - (3) M&S "AP" module: Application in current job position
  - (4) M&S "MA" module: Mastery in current job position
- 6) Module maturity: has it been taught, and if so, a brief history: TBD
  - 7) Number of hours estimated to deliver/teach module: 20 Hours
    - (1) General Awareness 3 hours
    - (2) Understanding 4 hours
    - (3) Application 7 hours
    - (4) Mastery 6 hours



## 8) Proposed Delivery modality:

- face-to-face, VTC, resident, customer's site.

- 9) Proposed references and texts: Text will be a current, entry-level M&S text to be identified by the instructor at time of delivery. Additional reference material will include current available literature selected by the instructor for practical application in support of the curriculum. Other supporting text/reference material will be student contributions of relevant material from their experience.

- Simulation Based Acquisition: A New Approach, Report of the Military Research Fellows DSMC 1997-1998- Reference text not known at this time.

## 10) Module learning objectives:

E6.1	Demonstrate competency to the level specified in E6 applied to acoustic wave propagation
E6.2	Demonstrate competency to the level specified in E6 applied to electromagnetic wave propagation
E6.3	Demonstrate competency to the level specified in E6 applied to acoustic communication systems
E6.4	Demonstrate competency to the level specified in E6 applied to electromagnetic communication systems
E6.5	Demonstrate competency to the level specified in E6 applied to acoustic active and passive detection systems
E6.6	Demonstrate competency to the level specified in E6 applied to acoustic active and passive detection systems

## 11) Course assessment plan (projects, exams, papers, etc.)

- Team projects/case studies, discussion, written questions.

## 12) Topic list by hour of instruction and reference:

The hours of instruction are categorized based on the level of competency required. As a result of this format the hour structure starts at a level of general awareness and progresses through mastery. This will allow the course material to be easily segmented into each one of the 4 levels of competency.

Hours	ESR Syllabus	Ref
1-3	Introduction and overview of acoustic and electromagnetic systems	Ref [1]
4.0	Student will demonstrate basic understanding of acoustic wave theory	Ref [1]
4.5	Student will demonstrate basic understanding of electromagnetic wave theory	Ref [1]

Hours	ESR Syllabus	Ref
5.0	Student will demonstrate basic understanding of communication systems	Ref [1]
5.5	Student will demonstrate basic understanding of electromagnetic communication systems	Ref [1]
6.0	Student will demonstrate basic understanding of acoustic active and passive detection systems	Ref [1]
7.0-9.5	Student will demonstrate basic understanding of electromagnetic active and passive detection systems	Ref [1]
9.5-11	Student will demonstrate ability to use M&S application techniques with respect to acoustic and communication systems	Ref [1]
11-12	Student will demonstrate ability to use M&S application techniques with respect to acoustic active and passive detection systems	Ref [1]
13-14	Student will demonstrate ability to use M&S application techniques with respect to electromagnetic active and passive detection systems	Ref [1]
15	Student will demonstrate use of M&S tools to perform analysis and evaluation of acoustic communication systems	Ref [1]
16	Student will demonstrate use of M&S tools to perform analysis and evaluation of electromagnetic communication systems	Ref [1]
17-18	Student will demonstrate use of M&S tools to perform analysis and evaluation of acoustic active and passive detection systems. Includes case studies and class projects	Ref [1]
19-20	Student will demonstrate use of M&S tools to perform analysis and evaluation of electromagnetic active and passive detection systems. Includes case studies and class projects	Ref [1]

Ref [1] TBD by NPS Partners.

**E7) Military Platform Systems Engineering**

**Apply a broad-based design oriented M&S approach for complex platforms that interact with air-land-sea-based hardware systems, command and control systems and combat systems.**

- 1) Module name: Military Platform Systems Engineering
- 2) Module coordinator: Marsha Taliaferro-Gillis, Ph.D.  
6596 Main Street  
Gloucester, VA 23061  
(804)694-3173 (Office)  
(804)824-4663 (Cell)  
mtgillis@werneranderson.com
- 3) Module description: Military Platform Systems Engineering - Apply a broad-based design oriented M&S approach for complex platforms that interact with air-land-sea-based hardware systems, command and control systems and combat systems.
- 4) ESRs that the module supports: E7
- 5) Prerequisites assumed, and corresponding level of mastery:
- 6) Module maturity: none
- 7) Number of hours estimated to teach: 26
- 8) Proposed Delivery modality: face-to-face, on-line, VTC, resident, customer's site
- 9) Proposed references and texts:

Bartolomei, Jason E. The Use of Systems Engineering Processes and Tools to Develop a System Dynamic Simulation Model of Engineering Support During the Development Phase of an Acquisition Program. Air Force Institute Of Technology, Wright-Patterson Air Force Base, OH School Of Engineering: 2001.

Kelton, W., A. Law. 2 000. *Simulation Modeling and Analysis*, Boston, MA.

Kossiakoff, Alexander; William N. Sweet. *Systems Engineering Principles and Practice*. Hoboken, NJ: John Wiley and Sons, 2003.

Sarjoughian, Hessam S. & Francois E. Cellier. *Discrete Event Modeling and Simulation Technologies: A Tapestry of Systems and AI-Based Theories and Methodologies*. New York: Springer-Verlag, 2001.

Test & Evaluation Management Guide, Fifth Edition. Fort Belvoir, VA: Defense Acquisition University Press: 2005.

## VV&A Recommended Practices Guide

### 10) Module learning objectives:

- E7.1 Identify key fundamental theoretical principles in systems engineering
- E7.2 Describe the role and benefits of M&S in systems engineering
- E7.3 Given a case study, understand key system characteristics of the system and component subsystems of interest
- E7.4 Given a case study, identify the key elements of the system and component subsystem to be modeled to meet the requirements of the specific use
- E7.5 Given a case study, apply or analyze the effectiveness of simulation tools used to evaluate the performance of the system and components subsystems
- E7.6 Describe the role of component-based and distributed simulation as it applies to the system and component subsystems
- E7.7 Given a case study, apply or analyze key M&S issues related to interaction of subsystems within a larger system
- E7.8 Given a case study, analyze the VV&A implication of using a simulation of a system that is sufficiently different from its intended use
- E7.9 Given a case study, analyze whether the system and component subsystems are modeled in sufficient detail to support program milestone decision requirements
- E7.10 Given a case study, analyze whether the system and component subsystems are modeled in sufficient detail to support T&E requirements

### 11) Course assessment plan: projects, and exams

### 12) Topic list by hour of instruction and reference.

#### *Competency Level: General Awareness*

- i) Hour 1: Identify key fundamental theoretical principles in systems engineering
  - Chapter 1, Systems Engineering and the World of Modern System
  - Kossiakoff, Alexander; William N. Sweet. *Systems Engineering Principles and Practice*. Hoboken, NJ: John Wiley and Sons, 2003.

#### *Competency Level: General Awareness*

- ii) Hour 2: Identify key fundamental theoretical principles in systems engineering
  - Chapter 3, The System Development Process

- Systems Engineering Through the System Life Cycle
- System Life Cycle
- Characteristics of the Development Process
- Testing Throughout System Development
- Kossiakoff, Alexander; William N. Sweet. *Systems Engineering Principles and Practice*. Hoboken, NJ: John Wiley and Sons, 2003.

*Competency Level: General Awareness*

- iii) Hour 3: Describe the role and benefits of M&S in systems engineering.
  - Chapter 14, Systems Engineering Decision Tools
  - Modeling through System Development
  - Modeling
  - Simulation
- Kossiakoff, Alexander; William N. Sweet. *Systems Engineering Principles and Practice*. Hoboken, NJ: John Wiley and Sons, 2003.

*Competency Level: Understanding*

- iv) Hour 4: Describe the role and benefits of M&S in systems engineering.
  - Chapter 14, Systems Engineering Decision Tools
  - Trade-Off Analysis
- Kossiakoff, Alexander; William N. Sweet. *Systems Engineering Principles and Practice*. Hoboken, NJ: John Wiley and Sons, 2003.

*Competency Level: General Awareness*

- v) Hour 5: Given a case study, understand key system characteristics of the system and component subsystems of interest.
  - Chapter 2, Structure of Complex Systems
  - System Building Blocks and Interfaces
  - Hierarchy of Complex Systems
  - System Building Blocks
- Kossiakoff, Alexander; William N. Sweet. *Systems Engineering Principles and Practice*. Hoboken, NJ: John Wiley and Sons, 2003.

*Competency Level: Understanding*

- vi) Hour 6: Given a case study, understand key system characteristics of the system and component subsystems of interest.
  - Chapter 2, Structure of Complex Systems
  - The System Environment
  - Interfaces and Interactions

- Kossiakoff, Alexander; William N. Sweet. *Systems Engineering Principles and Practice*. Hoboken, NJ: John Wiley and Sons, 2003.

*Competency Level: Application*

vii) Hour 7: Given a case study, identify the key elements of the system and component subsystem to be modeled to meet the requirements of the specific use.

- Specific Use
- Review Case Study

*Competency Level: Application*

viii) Hour 8: Given a case study, identify the key elements of the system and component subsystem to be modeled to meet the requirements of the specific use.

- Specific Use
- Review Case Study

*Competency Level: Mastery*

ix) Hour 9: Given a case study, identify the key elements of the system and component subsystem to be modeled to meet the requirements of the specific use.

- Specific Use
- Review Case Study

*Competency Level: Application*

x) Hour 10: Given a case study, apply or analyze the effectiveness of simulation tools used to evaluate the performance of the system and component subsystems.

- Chapter 9, Engineering Design
- Component Design
- Kossiakoff, Alexander; William N. Sweet. *Systems Engineering Principles and Practice*. Hoboken, NJ: John Wiley and Sons, 2003.

*Competency Level: Application*

xi) Hour 11: Given a case study, apply or analyze the effectiveness of simulation tools used to evaluate the performance of the system and component subsystems.

- Chapter 8, Advanced Development
- Functional Analysis and Design
- Prototype Development
- Development Testing
- Kossiakoff, Alexander; William N. Sweet. *Systems Engineering Principles and Practice*. Hoboken, NJ: John Wiley and Sons, 2003.

*Competency Level: Mastery*

- xii) Hour 12: Given a case study, apply or analyze the effectiveness of simulation tools used to evaluate the performance of the system and component subsystems.
- Chapter 10, Integration and Evaluation
  - Developmental System Testing
  - Kossiakoff, Alexander; William N. Sweet. *Systems Engineering Principles and Practice*. Hoboken, NJ: John Wiley and Sons, 2003.

*Competency Level: General Awareness*

- xiii) Hour 13: Describe the role of component-based and distributed simulation as it applies to the system and component subsystems.
- Chapter 2, Modeling Complex Systems
  - Chapter 1.6, Alternative Approaches to Modeling and Coding Simulations, Parallel and Distributed Simulation
  - Kelton, W., A. Law. 2000. *Simulation Modeling and Analysis*, Boston, MA.

*Competency Level: Understanding*

- xiv) Hour 14: Describe the role of component-based and distributed simulation as it applies to the system and component subsystems.
- Component Based Simulation

*Competency Level: Understanding*

- xv) Hour 15: Describe the role of component-based and distributed simulation as it applies to the system and component subsystems.
- Component Based Simulation

*Competency Level: Application*

- xvi) Hour 16: Given a case study, apply or analyze key M&S issues related to interaction of subsystems within a larger system.
- Interaction of subsystems
  - Chapter 10, Integration and Evaluation
  - Integrating, Testing, and Evaluation the Total System
  - System Integration
  - Kossiakoff, Alexander; William N. Sweet. *Systems Engineering Principles and Practice*. Hoboken, NJ: John Wiley and Sons, 2003.

*Competency Level: Mastery*

- xvii) Hour 17: Given a case study, apply or analyze key M&S issues related to interaction of subsystems within a larger system.
- Interaction of subsystems

- Chapter 10, Integration and Evaluation
- Integrating, Testing, and Evaluation the Total System
- System Integration
- Kossiakoff, Alexander; William N. Sweet. *Systems Engineering Principles and Practice*. Hoboken, NJ: John Wiley and Sons, 2003.

*Competency Level: Understanding*

- xviii) Hour 18: Given a case study, analyze the VV&A implication of using a simulation of a system that is sufficiently different from its intended use.
- VV&A
  - Intended Use
  - VV&A Recommended Practices Guide

*Competency Level: Mastery*

- xix) Hour 19: Given a case study, analyze the VV&A implication of using a simulation of a system that is sufficiently different from its intended use.
- Implications of modifying M&S for different purposes

*Competency Level: Mastery*

- xx) Hour 20: Given a case study, analyze the VV&A implication of using a simulation of a system that is sufficiently different from its intended use.
- Implications of modifying M&S for different purposes

*Competency Level: Understanding*

- xxi) Hour 21: Given a case study, analyze whether the system and component subsystems are modeled in sufficient detail to support program milestone decision requirements.
- CJCSI 3170.01
  - DoD 5000 series
  - Acquisition Cycle Milestones

*Competency Level: Mastery*

- xxii) Hour 22: Given a case study, analyze whether the system and component subsystems are modeled in sufficient detail to support program milestone decision requirements.
- Implications of modifying M&S for different purposes

*Competency Level: Mastery*

- xxiii) Hour 23: Given a case study, analyze whether the system and component subsystems are modeled in sufficient detail to support program milestone decision requirements.



- The Use of Systems Engineering Processes and Tools to Develop a System Dynamic Simulation Model of Engineering Support During the Development Phase of an Acquisition Program
- Bartolomei, Jason E. *The Use of Systems Engineering Processes and Tools to Develop a System Dynamic Simulation Model of Engineering Support During the Development Phase of an Acquisition Program* Air Force Institute Of Technology, Wright-Patterson Air Force Base, OH School Of Engineering: 2001.

*Competency Level: Understanding*

- xxiv) Hour 24: Given a case study, analyze whether the system and component subsystems are modeled in sufficient detail to support T&E requirements.
- Chapter 14, Modeling and Simulation Support to T&E
  - Types of Models and Simulations
  - Validity of Modeling and Simulation
  - Test & Evaluation Management Guide, Fifth Edition. Fort Belvoir, VA: Defense Acquisition University Press: 2005.

*Competency Level: Mastery*

- xxv) Hour 25: Given a case study, analyze whether the system and component subsystems are modeled in sufficient detail to support T&E requirements.
- Chapter 14, Modeling and Simulation Support to T&E
  - Support to Test Design and Planning
  - Support to Test Execution
  - Support to Analysis and Test Reporting
  - Test & Evaluation Management Guide, Fifth Edition. Fort Belvoir, VA: Defense Acquisition University Press: 2005.

*Competency Level: Mastery*

- xxvi) Hour 26: Given a case study, analyze whether the system and component subsystems are modeled in sufficient detail to support T&E requirements.
- Chapter 14, Modeling and Simulation Support to T&E
  - Simulation Integration
  - Simulation Planning
  - Test & Evaluation Management Guide, Fifth Edition. Fort Belvoir, VA: Defense Acquisition University Press: 2005.

## **E8) Computers**

**Describe the basic computer system architecture, operating systems, networking and introduction to engineering software and their applications. Classify structured programming languages such as Fortran and C, and the use of such tools for code development. Recognize finite element/difference codes, with application to solve engineering problems including experience with selected software packages.**

*Course Name:* Applying Computer Technology and Army Training Modeling and Simulation (M&S) Applications in Support of Acquisition

*Course Coordinator:*

Michael D. Proctor, Ph.D., LTC (Retired)

Associate Professor, CMSP

IEMS & IDS M&S

University of Central Florida

Engineering Building 2, Room 301-D

Tel: 407-823-5296

Fax: 407-823-3413

[mproctor@mail.ucf.edu](mailto:mproctor@mail.ucf.edu)

<http://people.cecs.ucf.edu/proctor>

*Course Description:*

This course will provide an *application capability* of the theoretical fundamentals of basic computer system software tools and Army Training Modeling and Simulation applications that are used in support of acquisition. Exposure to practical Army training modeling and simulation (M&S) applications as system life cycle management tools in support of Simulation-based Acquisition (SBA) will be through cases.

*Modules incorporated into Course:*

This course incorporates material covered in the Awareness and Understanding courses (modules) and will reuse the Awareness level online course learning module as is if developed.

*ESR Supporting the Course*

ESR E8. Sub ESRs taught at the application level.

*Pre-requisite*

1. Rank/Seniority:

Active Military: O-1 and above

Government Civilian: GS-5 and above

2. Pre-Course/Training:

CLE011 and CLE023 or equivalent

*Course Maturity*

New course.

*Contact Hours / Pace of Completion*

This is a 3-day course with 24 contact hours. The course can be completed with 8hr-instruction per day.

*Proposed Delivery Modality*

The course is a mixture of face-to-face teaching and will reuse the Awareness level online course learning module if the online course (module) is developed.

*Proposed Reference and Text*

- Case Study to be developed with PEO STRI on Live Training Simulation in Acquisition (OneTESS)
- Case Study to be developed with PEO STRI on Constructive Training Simulation in Acquisition (OneSAF Objective System)
- Case Study to be developed with IBM on Rational
- OUSD (AT&L) (2006). *Acquisition Modeling and Simulation Master Plan*. Department of Defense.
- Piplani Lalik, Mercer Joseph, Roop Richard (1994). *Systems Acquisition Manager's Guide for the Use of Models and Simulations*. Defense Systems Management College.
- Proctor (Editor) (1999) *Web-based Technical Reference on Simulation Interoperability*
- Proctor Michael, Posey-Macalintal Amy, Kulonda Dennis (2003). *Why the "T" in SMART: A Constructive Synergy*. Acquisition Review Quarterly Summer 2003: 285-299
- Proctor Michael, Lipinski Michael (2000). Technical Performance Measures and Distributed-Simulation Training Systems. Acquisition Review Quarterly Winter 2000: 19-32
- Sherman William, Craig Alan (2003). *Understanding Virtual Reality*. Morgan Kaufman Publishers.
- Woodridge Michael (2002). *Multiagent Systems*. John Wiley & Sons.

*Course Learning Objectives*

Students who have successfully completed this course will be able to:

1. E8.1 Relates basic computer system architecture, operating systems, networking, introductory engineering software and their application to Modeling and Simulation (M&S) applications, introductory structured programming languages such as Fortran and C, and the use of such languages for software development
2. E8.2 Applies the use of selected Runtime software systems to build M&S scenarios to support PMs, SEs, and T&E requirements across the acquisition life cycle.

3. E8.3 Applies the use of selected Intelligent Agent software systems to build M&S scenarios to support PMs, SEs, and T&E requirements across the acquisition life cycle.
4. E8.4 Applies M&S, interoperability, and intelligent agent software tools to build massively online systems (to include gaming systems) so as to support PMs, SEs, and T&E requirements across the acquisition life cycle.
5. E8.5 Predicts alternative Live training M&S systems in support of training and T&E requirements across the acquisition life cycle.
6. E8.6 Predicts alternative virtual training M&S systems in support PMs, SEs, and T&E requirements across the acquisition life cycle.
7. E8.7 Applies Computer Assisted System Engineering tools to support project life cycle development/engineering.

### *Course Assessment Plan*

Verbal Feedback during Class- to periodically check on students' understanding of topics taught

End-of-Course Evaluation- open and closed questions to test student's proficiency on the topics taught

Hands-on Software Training and Scenario-based Testing- short scenario-based assignment similar to case studies taught to test students' ability in M&S software usage

### Hour-by-hour Instruction

Hour 1: Relates basic computer systems, M&S tools for acquisition (E8.1)

Hour 2: Applies Modeling Software Authoring for acquisition (E8.2)

Hour 3: Applies Runtime Software for acquisition (Presagis Vega and AIS SVS) (E8.2)

Hour 4: Applies Intelligent Agent Software for acquisition (OneSAF, Mak VR Forces, SimBionic) (E8.3)

Hour 5: Applies M&S Software with Authoring Tools (E8.2 & E8.3)

Hour 6: Applies M&S Software with Authoring Tools (E8.2 & E8.3)

Hour 7: Predicts Lab-based Acquisition Evaluation- Experimental Design with Authoring Tools (E8.2 & E8.3)

Hour 8: Predicts Lab-based Acquisition Evaluation- Experimental Design with Authoring Tools (E8.2 & E8.3)

Above 8 hours supported by:

Case Study to be developed with PEO STRI on Constructive Training Simulation in Acquisition (OneSAF Objective System)

Piplani Lalik, Mercer Joseph, Roop Richard (1994). *Systems Acquisition Manager's Guide for the Use of Models and Simulations*. Defense Systems Management College.

OUSD (AT&L) (2006). *Acquisition Modeling and Simulation Master Plan*. Department of Defense.

Proctor (Editor) (1999) *Web-based Technical Reference on Simulation Interoperability*

Sherman William, Craig Alan (2003). *Understanding Virtual Reality*. Morgan Kaufman Publishers.

Woodridge Michael (2002). *Multiagent Systems*. John Wiley & Sons.

Hour 9: Applies massively online M&S Systems to include games for acquisition (E8.4)

Hour 10: Applies massively scenario with Online system (E8.4)

Hour 11: Applies massively scenario with Online system (E8.4)

Hour 12: Applies massively scenario with Online system (E8.4)

Hour 13: Predicts Lab-based Acquisition Evaluation- Experimental Design with Online Systems (E8.4)

Hour 14: Predicts Lab-based Acquisition Evaluation- Experimental Design with Online Systems (E8.4) (45 hour course would have one additional hour)

Above 6 hours supported by:

Proctor (Editor) (1999) *Web-based Technical Reference on Simulation Interoperability*

Sherman William, Craig Alan (2003). *Understanding Virtual Reality*.

Morgan Kaufman Publishers.

Woodridge Michael (2002). *Multiagent Systems*. John Wiley & Sons.

Hour 15: Diagram SMART Snake Chart Structure and Concept for Live Training M&S for acquisition (E8.5)

Hour 16: Relate Live Training M&S for Acquisition (OneTESS) (E8.5)

Hour 17: Predict Live Training M&S Case Study (OneTESS) (E8.5)

Above 3 hours supported by:

Case Study to be developed with PEO STRI on Live Training Simulation in Acquisition (OneTESS)

Hour 18: Diagram SMART Snake Chart Structure and Concept for Virtual Training M&S for acquisition (E8.6)

Hour 19: Relate Virtual Training M&S for Acquisition (CCTT) (E8.6)

Hour 20: Predict Virtual Training M&S Case Study (CCTT) (E8.6)

Above 3 hours supported by:

Proctor Michael, Posey-Macalintal Amy, Kulonda Dennis (2003). *Why the "T" in SMART: A Constructive Synergy*. Acquisition Review Quarterly Summer 2003: 285-299

Proctor Michael, Lipinski Michael (2000). Technical Performance Measures and Distributed-Simulation Training Systems. Acquisition Review Quarterly Winter 2000: 19-32

Hour 21: Apply Computer Assisted System Engineering software (E8.7)

Hour 22: Apply Computer Aided System Engineering Case Study (E8.7)

Hour 23: Apply Computer Aided System Engineering Case Study(E8.7)  
Case Study to be developed with IBM on Rational

Hour 24: Conclusion and End-of-Course Evaluation

---

*Course Name:* Awareness of Commercial Simulation-Based Acquisition Metaphors

*Course Coordinator*

Michael D. Proctor, Ph.D., LTC (Retired)

Associate Professor, CMSP

IEMS & IDS M&S

University of Central Florida

Engineering Building 2, Room 301-D

Tel: 407-823-5296

Fax: 407-823-3413

[mproctor@mail.ucf.edu](mailto:mproctor@mail.ucf.edu)

<http://people.cecs.ucf.edu/proctor>

*Course Description:*

This course will provide a *general awareness* of the essential skill requirements of basic computer system software tools and Army Training Modeling and Simulation applications that are used in support of acquisition. Exposure to practical Army training modeling and simulation (M&S) applications as system life cycle management tools in support of Simulation-based Acquisition (SBA) will be through cases.

*Modules incorporated into Course:*

This course is a basic entry course or a fundamental module. This course can be incorporated as a module into the Introduction, Application, and Masters level course offerings related to this same ESR.

*ESR Supporting the Course*

ESR E8. General Awareness for each sub ESR.

*Pre-requisite*

1. Rank/Seniority:  
Active Military: O-1 and above  
Government Civilian: GS-5 and above
2. Pre-Course/Training:  
CLE011 and CLE023 or equivalent

*Course Maturity*

New course.

*Contact Hours / Pace of Completion*

This is a non-Resident, self paced 3 hr-online course that may take between 2 and 6 hours depending of the prior experience and skills of the students. Students must pass the End-of-Course test within 30 calendar days of the start date.

*Proposed Delivery Modality*

Online learning course.

*Proposed Reference and Text*

- e Study to be developed with PEO STRI on Live Training Simulation in Acquisition (OneTESS)
- Case Study to be developed with PEO STRI on Constructive Training Simulation in Acquisition (OneSAF Objective System)
- Case Study to be developed with IBM on Rational
- OUSD (AT&L) (2006). *Acquisition Modeling and Simulation Master Plan*. Department of Defense.
- Piplani Lalik, Mercer Joseph, Roop Richard (1994). *Systems Acquisition Manager's Guide for the Use of Models and Simulations*. Defense Systems Management College.
- Proctor (Editor) (1999) Web-based Technical Reference on Simulation Interoperability
- Proctor Michael, Posey-Macalintal Amy, Kulonda Dennis (2003). *Why the "T" in SMART: A Constructive Synergy*. Acquisition Review Quarterly Summer 2003: 285-299

- Proctor Michael, Lipinski Michael (2000). Technical Performance Measures and Distributed-Simulation Training Systems. Acquisition Review Quarterly Winter 2000: 19-32
- Sherman William, Craig Alan (2003). *Understanding Virtual Reality*. Morgan Kaufman Publishers.
- Woodridge Michael (2002). *Multiagent Systems*. John Wiley & Sons.

### *Course Learning Objectives*

Students who have successfully completed this course will be able to:

1. E8.1 Identifies basic computer system architecture, operating systems, networking, introductory engineering software and their application to Modeling and Simulation (M&S) applications, introductory structured programming languages such as Fortran and C, and the use of such languages for software development
2. E8.2 Recalls the use of selected Modeling and Runtime software systems to build M&S scenarios to support PMs, SEs, and T&E requirements across the acquisition life cycle.
3. E8.3 Recalls the use of selected Intelligent Agent software systems to build M&S scenarios to support PMs, SEs, and T&E requirements across the acquisition life cycle.
4. E8.4 Recalls M&S, interoperability, and intelligent agent software tools to build massively online systems (to include gaming systems) so as to support PMs, SEs, and T&E requirements across the acquisition life cycle.
5. E8.5 Knows alternative Live training M&S systems in support of training and T&E requirements across the acquisition life cycle.
6. E8.6 Knows alternative virtual training M&S systems in support PMs, SEs, and T&E requirements across the acquisition life cycle.
7. E8.7 Identifies Computer Assisted System Engineering tools to support project life cycle development/engineering.

### *Course Assessment Plan*

Sectional Reviews- sets of multiple choice questions specific to each topic at the end of each course section

End-of-Course Test- general multiple choice questions on all topics taught

### *Hour-by-hour Instruction*

Hour 1: Overview of computer systems and terminology Modeling, Runtime Software, Intelligent Agent Software, Massively Online Systems. (ESR E8.1 E8.2, E8.3, E8.4)

Hour 2: Introduction to Live and Virtual Training M&S for Acquisition (ESR E8.5, E8.6)



Hour 3: Introduction to CASE tools for Acquisition, Conclusion, End-of-Course Test (ESR E8.7)

---

*Course Name:* Understanding Computer Technology and Army Training Modeling and Simulation (M&S) Applications in Support of Acquisition

*Course Coordinator*

Michael D. Proctor, Ph.D., LTC (Retired)

Associate Professor, CMSP

IEMS & IDS M&S

University of Central Florida

Engineering Building 2, Room 301-D

Tel: 407-823-5296

Fax: 407-823-3413

[mproctor@mail.ucf.edu](mailto:mproctor@mail.ucf.edu)

<http://people.cecs.ucf.edu/proctor>

*Course Description*

This course will provide an *understanding* of the theoretical fundamentals of basic computer system software tools and Army Training Modeling and Simulation applications that are used in support of acquisition. Exposure to practical Army training modeling and simulation (M&S) applications as system life cycle management tools in support of Simulation-based Acquisition (SBA) will be through cases.

*Modules incorporated into Course:*

This course incorporates ESR A2 material covered in the Awareness course (modules).

*ESR Supporting the Course*

ESR E8. Taught at understanding level of each sub ESR

*Pre-requisite*

1. Rank/Seniority:

Active Military: O-1 through O-4 and above

Government Civilian: GS-5 through GS-13 and above

2. Pre-Course/Training:

CLE011 and CLE023

*Course Maturity*

New course.

*Contact Hours / Pace of Completion*

This is a one-day seminar with 8 contact hours.

*Proposed Delivery Modality*

The course is a mixture of face-to-face teaching and will reuse the Awareness level content and the corresponding online course learning module if the online course (module) is developed.

### *Proposed Reference and Text*

- Case Study to be developed with PEO STRI on Live Training Simulation in Acquisition (OneTESS)
- Case Study to be developed with PEO STRI on Constructive Training Simulation in Acquisition (OneSAF Objective System)
- Case Study to be developed with IBM on Rational
- OUSD (AT&L) (2006). *Acquisition Modeling and Simulation Master Plan*. Department of Defense.
- Piplani Lalik, Mercer Joseph, Roop Richard (1994). *Systems Acquisition Manager's Guide for the Use of Models and Simulations*. Defense Systems Management College.
- Proctor (Editor) (1999) *Web-based Technical Reference on Simulation Interoperability*
- Proctor Michael, Posey-Macalintal Amy, Kulonda Dennis (2003). *Why the "T" in SMART: A Constructive Synergy*. Acquisition Review Quarterly Summer 2003: 285-299
- Proctor Michael, Lipinski Michael (2000). Technical Performance Measures and Distributed-Simulation Training Systems. Acquisition Review Quarterly Winter 2000: 19-32
- Sherman William, Craig Alan (2003). *Understanding Virtual Reality*. Morgan Kaufman Publishers.
- Woodridge Michael (2002). *Multiagent Systems*. John Wiley & Sons.

### *Course Learning Objectives*

Students who have successfully completed this course will be able to:

1. E8.1 Comprehends basic computer system architecture, operating systems, networking, introductory engineering software and their application to Modeling and Simulation (M&S) applications, introductory structured programming languages such as Fortran and C, and the use of such languages for software development
2. E8.2 Distinguishes the use of selected Runtime software systems to build M&S scenarios to support PMs, SEs, and T&E requirements across the acquisition life cycle.
3. E8.3 Comprehends the use of selected Intelligent Agent software systems to build M&S scenarios to support PMs, SEs, and T&E requirements across the acquisition life cycle.
4. E8.4 Comprehends M&S, interoperability, and intelligent agent software tools to build massively online systems (to include gaming systems) so as to support PMs, SEs, and T&E requirements across the acquisition life cycle.
5. E8.5 Comprehends alternative Live training M&S systems in support of training and T&E requirements across the acquisition life cycle.

6. E8.6 Comprehends alternative virtual training M&S systems in support PMs, SEs, and T&E requirements across the acquisition life cycle.
7. E8.7 Comprehends Computer Assisted System Engineering tools to support project life cycle development/engineering.

### *Course Assessment Plan*

Verbal Feedback during Class- to periodically check on students' understanding of topics taught

End-of-Course Evaluation- via group discussion, presentation and sharing

### Hour-by-hour Instruction

Hour 1: Comprehends basic computer systems, M&S tools for acquisition (E8.1)

Hour 2: Distinguishes Modeling Software, Runtime Software

Hour 3: Comprehends Intelligent Agent Software for acquisition (OneSAF, Mak VR Forces, SimBionic) (E8.3)

Above 3 hours supported by:

Case Study to be developed with PEO STRI on Constructive Training Simulation in Acquisition (OneSAF Objective System)

Piplani Lalik, Mercer Joseph, Roop Richard (1994). *Systems Acquisition Manager's Guide for the Use of Models and Simulations*. Defense Systems Management College.

OUSD (AT&L) (2006). *Acquisition Modeling and Simulation Master Plan*. Department of Defense.

Proctor (Editor) (1999) *Web-based Technical Reference on Simulation Interoperability*

Sherman William, Craig Alan (2003). *Understanding Virtual Reality*. Morgan Kaufman Publishers.

Woodridge Michael (2002). *Multiagent Systems*. John Wiley & Sons.

Hour 4: Comprehends massively online M&S Systems to include games for acquisition (E8.4)

Proctor (Editor) (1999) *Web-based Technical Reference on Simulation Interoperability*

Sherman William, Craig Alan (2003). *Understanding Virtual Reality*. Morgan Kaufman Publishers.

Woodridge Michael (2002). *Multiagent Systems*. John Wiley & Sons.

Hour 5: Comprehends potential for Live Training M&S for use in Acquisition (OneTESS) (E8.5)

Case Study to be developed with PEO STRI on Live Training Simulation in Acquisition (OneTESS)

Hour 6: Comprehends potential for Virtual Training M&S for Acquisition (CCTT) (E8.6)

Proctor Michael, Posey-Macalintal Amy, Kulonda Dennis (2003). *Why the "T" in SMART: A Constructive Synergy*. Acquisition Review Quarterly Summer 2003: 285-299

Proctor Michael, Lipinski Michael (2000). Technical Performance Measures and Distributed-Simulation Training Systems. Acquisition Review Quarterly Winter 2000: 19-32

Hour 7: Comprehends Computer Assisted System Engineering software applicability to acquisition (E8.7)

Case Study to be developed with IBM on Rational

Hour 8: Conclusion and End-of-Course Evaluation

---

Course Name: Computer Technology and Army Training Modeling and Simulation (M&S) Applications in Support of Acquisition

*Course Coordinator:*

Michael D. Proctor, Ph.D., LTC (Retired)  
Associate Professor, CMSP  
IEMS & IDS M&S  
University of Central Florida  
Engineering Building 2, Room 301-D  
Tel: 407-823-5296  
Fax: 407-823-3413  
[mproctor@mail.ucf.edu](mailto:mproctor@mail.ucf.edu)  
<http://people.cecs.ucf.edu/proctor>

*Course Description:*

This course seeks to provide an *educational mastery* (a masters level course that is part of a masters program in modeling and simulation) of essential skill requirements of basic computer system software tools and Army Training Modeling and Simulation applications that are used in support of acquisition. Exposure to practical Army training modeling and simulation (M&S) applications as system life cycle management tools in support of Simulation-based Acquisition (SBA) will be through cases.

*Modules incorporated into Course:*

This course incorporates ESR A2 material covered in the Awareness, Understanding, and Application courses (modules) and will reuse the Awareness level online course learning module if developed.

*ESR Supporting the Course*

ESR E8. Sub ESR taught at Educational Mastery (part of a masters program) competency level or at the maximum level specified in the matrix.

*Pre-requisite*

1. Rank/Seniority:  
Active Military: O-3 and above  
Government Civilian: GS-9 and above
2. Pre-Course/Training:  
CLE011 and CLE023 or equivalent

*Course Maturity*

New course.

*Contact Hours / Pace of Completion*

This is a quarter or semester-long (12 to 15 weeks) course with 36 to 45 contact hours with 3hr-instruction per week. Alternatively the course may be accomplished in a shorter period of time covering the same number of contact hours but with a faster paced setting being 6 hours per week.

*Proposed Delivery Modality*

The course is a mixture of face-to-face teaching and will reuse the Awareness level online course learning module if the online course (module) is developed.

*Proposed Reference and Text*

- Case Study to be developed with PEO STRI on Live Training Simulation in Acquisition (OneTESS)
- Case Study to be developed with PEO STRI on Constructive Training Simulation in Acquisition (OneSAF Objective System)
- Case Study to be developed with IBM on Rational
- OUSD (AT&L) (2006). *Acquisition Modeling and Simulation Master Plan*. Department of Defense.
- Piplani Lalik, Mercer Joseph, Roop Richard (1994). *Systems Acquisition Manager's Guide for the Use of Models and Simulations*. Defense Systems Management College.
- Proctor (Editor) (1999) *Web-based Technical Reference on Simulation Interoperability*
- Proctor Michael, Posey-Macalintal Amy, Kulonda Dennis (2003). *Why the "T" in SMART: A Constructive Synergy*. Acquisition Review Quarterly Summer 2003: 285-299

- Proctor Michael, Lipinski Michael (2000). Technical Performance Measures and Distributed-Simulation Training Systems. Acquisition Review Quarterly Winter 2000: 19-32
- Sherman William, Craig Alan (2003). *Understanding Virtual Reality*. Morgan Kaufman Publishers.
- Woodridge Michael (2002). *Multiagent Systems*. John Wiley & Sons.

### *Course Learning Objectives*

Students who have successfully completed this course will be able to:

1. ESR E8.1 Compare and contrast basic computer system architecture, operating systems, networking, introductory engineering software and their application to Modeling and Simulation (M&S) applications, introductory structured programming languages such as Fortran and C, and the use of such languages for software development
2. ESR E8.2 Compare and contrast the use of selected Modeling and Runtime software systems to build M&S scenarios to support PMs, SEs, and T&E requirements across the acquisition life cycle.
3. ESR E8.3 Compare and Contrast the use of selected Intelligent Agent software systems to build M&S scenarios to support PMs, SEs, and T&E requirements across the acquisition life cycle.
4. ESR E8.4 Compare and Contrast M&S, interoperability, and intelligent agent software tools to build massively online systems (to include gaming systems) so as to support PMs, SEs, and T&E requirements across the acquisition life cycle.
5. ESR E8.5 Compare and Contrast alternative Live training M&S systems in support of training and T&E requirements across the acquisition life cycle.
6. ESR E8.6 Compare and Contrast alternative virtual training M&S systems in support PMs, SEs, and T&E requirements across the acquisition life cycle.
7. ESR E8.7 Compare and Contrast Computer Assisted System Engineering tools to support project life cycle development/engineering.

### *Course Assessment Plan*

Verbal Feedback during Class- to periodically check on students' understanding of topics taught

Term Papers- research-based projects to test students' ability to synthesize knowledge and draw conclusions based on knowledge learnt in class

Lab-based Project- open-ended practical project to test students' hands-on and cognitive ability to design experiments and demonstrate M&S software applications

End-of-Course Evaluation- open-ended and closed questions to test student's tacit knowledge in subject matter

Hour-by-hour Instruction

Hour 1: Compare and contrast basic computer systems, M&S tools for acquisition (E8.1)

Hour 2: Compare and contrast Modeling Software Authoring for acquisition (E8.2)

Hour 3: Compare and contrast Runtime Software for acquisition (Presagis Vega and AIS SVS) (The 45 hour course would have 3 hours on each topic) (E8.2)

Hour 4: Compare and contrast Intelligent Agent Software for acquisition (OneSAF, Mak VR Forces, SimBionic) (E8.3)

Hour 5: Compose M&S Software with Authoring Tools (E8.2 & E8.3)

Hour 6: Compose M&S Software with Authoring Tools (E8.2 & E8.3)

Hour 7: Infers Lab-based Acquisition Evaluation- Experimental Design with Authoring Tools (E8.2 & E8.3)

Hour 8: Infers Lab-based Acquisition Evaluation- Experimental Design with Authoring Tools (E8.2 & E8.3)

Above 8 hours supported by:

Case Study to be developed with PEO STRI on Constructive Training Simulation in Acquisition (OneSAF Objective System)

Piplani Lalik, Mercer Joseph, Roop Richard (1994). *Systems Acquisition Manager's Guide for the Use of Models and Simulations*. Defense Systems Management College.

OUUSD (AT&L) (2006). *Acquisition Modeling and Simulation Master Plan*. Department of Defense.

Proctor (Editor) (1999) *Web-based Technical Reference on Simulation Interoperability*

Sherman William, Craig Alan (2003). *Understanding Virtual Reality*. Morgan Kaufman Publishers.

Woodridge Michael (2002). *Multiagent Systems*. John Wiley & Sons.

Hour 9: Compare and contrast massively online M&S Systems to include games for acquisition (E8.4)

Hour 10: Compose massively scenario with Online system (E8.4)

Hour 11: Compose massively scenario with Online system (E8.4)

Hour 12: Compose massively scenario with Online system (E8.4)

Hour 13: Infer Lab-based Acquisition Evaluation- Experimental Design with Online Systems (E8.4)

Hour 14: Infer Lab-based Acquisition Evaluation- Experimental Design with Online Systems (E8.4) (45 hour course would have one additional hour)

Above 6 hours supported by:

Proctor (Editor) (1999) *Web-based Technical Reference on Simulation Interoperability*

Sherman William, Craig Alan (2003). *Understanding Virtual Reality*. Morgan Kaufman Publishers.

Woodridge Michael (2002). *Multiagent Systems*. John Wiley & Sons.

Hour 15: Diagram SMART Snake Chart Structure and Concept for Live Training M&S for acquisition (E8.5)

Hour 16: Compare and Contrast Live Training M&S for Acquisition (OneTESS) (E8.5)

Hour 17: Analyze Live Training M&S Case Study (OneTESS) (E8.5)

Above 3 hours supported by:

Case Study to be developed with PEO STRI on Live Training Simulation in Acquisition (OneTESS)

Hour 18: Diagram SMART Snake Chart Structure and Concept for Virtual Training M&S for acquisition (E8.6)

Hour 19: Compare and Contrast Virtual Training M&S for Acquisition (CCTT) (E8.6)

Hour 20: Analyze Virtual Training M&S Case Study (CCTT) (E8.6)

Above 3 hours supported by:

Proctor Michael, Posey-Macalintal Amy, Kulonda Dennis (2003). *Why the "T" in SMART: A Constructive Synergy*. Acquisition Review Quarterly Summer 2003: 285-299

Proctor Michael, Lipinski Michael (2000). Technical Performance Measures and Distributed-Simulation Training Systems. Acquisition Review Quarterly Winter 2000: 19-32

Hour 21: Discuss with Guest Lecture Live, Virtual, and Constructive Training simulation use for acquisition (E8.2, E8.5 and E8.6)



Hour 22: Discuss with Guest Lecture Live, Virtual, and Constructive Training simulation use for acquisition (E8.2, E8.5 and E8.6)

Hour 23: Discuss with Guest Lecture Live, Virtual, and Constructive Training simulation use for acquisition (E8.2, E8.5 and E8.6)

Above 3 hours to be supported with

Case Study to be developed with PEO STRI on Constructive Training Simulation in Acquisition (OneSAF Objective System)

Case Study to be developed with PEO STRI on Live Training Simulation in Acquisition (OneTESS)

Proctor Michael, Posey-Macalintal Amy, Kulonda Dennis (2003). *Why the "T" in SMART: A Constructive Synergy*. Acquisition Review Quarterly Summer 2003: 285-299

Proctor Michael, Lipinski Michael (2000). Technical Performance Measures and Distributed-Simulation Training Systems. Acquisition Review Quarterly Winter 2000: 19-32

Hour 24: Compare and Contrast Computer Assisted System Engineering software (E8.7)

Hour 25: Compose Computer Aided System Engineering Case Study (E8.7)

Hour 26: Compose Computer Aided System Engineering Case Study (E8.7) (45 hour course would have 3 additional hours)

Hour 27: Infer Lab-based System Acquisition with Computer-Aided System Engineering Tools (E8.7)

Hour 28: Infer Lab-based System Acquisition with Computer-Aided System Engineering Tools (E8.7)

Hour 29: Infer Lab-based System Acquisition with Computer-Aided System Engineering Tools (E8.7)

Above 6 hours supported by

Case Study to be developed with IBM on Rational

Hour 30 - 35: Student Term Paper Presentation and Sharing (All ESRs and references)

Hour 36: Conclusion and End-of-Course Evaluation

*\* Note the above syllabus is a best estimate for time, content, and references at the time of writing and is subject to change at any time.*

**E9) Electrical Engineering**

**Describe basic circuit analysis including DC and AC circuits. Describe the construction and operating characteristics of rotating machinery, static converters, power distribution systems and multi-phased circuits.**

- 1) Module name: Circuit design and AC/DC power distribution
- 2) Module coordinator/POC: Anthony Genna  
UCSD Extension  
Assistant Director,  
Defense Technology  
agenna@ucsd.edu  
858-603-2170 (cell)
- 3) Module description: Electrical Engineering - Describe basic circuit analysis including DC and AC circuits. Describe the construction and operating characteristics of rotating machinery, static converters, power distribution systems and multi-phased circuits.
- 4) ESR's that the module supports and the corresponding level of mastery: E9
- 5) Prerequisites assumed, and corresponding level of mastery: training and education (i.e., BS/MS degree or DAU/DoD courses, certifications, etc.) meeting requirements of current position and/or rank/grade/rate.

In addition it is recommended that student have academic training or OJT equivalent to the following levels of competency:

- (1) M&S "GA" module: General Awareness in current job position
  - (2) M&S "UN" module: Understanding in current job position
  - (3) M&S "AP" module: Application in current job position
  - (4) M&S "MA" module: Mastery in current job position
- 6) Module maturity: has it been taught, and if so, a brief history: TBD
  - 7) Number of hours estimated to deliver/teach module: 24
    - a) General Awareness 2 hours
    - b) Understanding 4 hours
    - c) Application 10 hours
    - d) Mastery 8 hours
  - 8) Proposed Delivery modality (face-to-face, VTC, resident, customer's site)
  - 9) Proposed references and texts: Text will be a current, entry-level M&S text to be identified by the instructor at time of delivery. Additional reference material will include current available literature selected by the instructor for practical application

in support of the curriculum. Other supporting text/reference material will be student contributions of relevant material from their experience.

- Simulation Based Acquisition: A New Approach, Report of the Military Research Fellows DSMC 1997-1998
- references and texts:
  1. *Analog and Digital Circuits for Electronic Control Systems Applications* describes sensors, I/O signals, how to deal with them, and the operations of embedded microcontrollers. It has real-world examples and author Gerald Luecke leads the reader through a hands-on project, using the TI MSP430 microcontroller. An accompanying CD contains application notes, code for software examples and problem solutions. ISBN 0750678100, \$49.95.
  2. *TBD.....*

10) Module learning objectives:

E9.1	Demonstrate competency to the level specified in E9 for M&S tools applied to the design and analysis of basic AC and DC circuits
E9.2	Demonstrate competency to the level specified in E9 for M&S tools applied to AC and DC motors and power distribution. This includes: construction and operating characteristics of rotating machinery, static converters, power distribution systems and multi-phased circuits.
E9.3	Demonstrate competency to the level specified in E9 for M&S tools that are used to perform system trade-off's between AC and DC motors and power distribution systems. This includes: construction and operating characteristics of rotating machinery, static converters, power distribution systems and multi-phased circuits
E9.4	Demonstrate competency to the level specified in E9 for M&S tools used to evaluate military AC and DC motors and power distribution systems. This includes: construction and operating characteristics of rotating machinery, static converters, power distribution systems and multi-phased circuits.

11) Course assessment plan (projects, exams, papers, etc.)

Team projects/case studies, discussion, written questions

12) Topic list by hour of instruction and reference:

The hours of instruction are categorized based on the level of competency required. As a result of this format the hour structure starts at a level of general awareness and progresses through mastery. This will allow the course material to be easily segmented into each one of the 4 levels of competency.

Hours	ESR Syllabus	Ref
1-2	Introduction and overview of basic circuit analysis including DC and AC circuits, the construction and operating characteristics of rotating machinery, static converters, power distribution systems and multi-phased circuits.	Ref [1]
3	Student will demonstrate basic understanding of M&S tools applied to AC/DC circuits	Ref [1]
4	Student will demonstrate basic understanding of M&S tools applied to AC/DC of AC and DC power device construction and operating characteristics of rotating machinery, static converters, power distribution systems and multi-phased circuits.	Ref [1]
5	Student will demonstrate basic understanding of M&S tools used to perform system trade-off's between AC and DC motors and power distribution systems. This includes the construction and operating characteristics of rotating machinery, static converters, power distribution systems and multi-phased circuits	Ref [1]
6	Student will demonstrate basic understanding of M&S tools used in military AC and DC motors and power distribution systems.	Ref [1]
7-9	Student will demonstrate ability to use M&S application techniques that support AC and DC motors and power distribution system development. This includes the construction and operating characteristics of rotating machinery, static converters, power distribution systems and multi-phased circuits	Ref [1]
10-12	Student will demonstrate ability to use M&S application techniques that are used to perform system trade-off's between AC and DC motors and power distribution systems. construction and operating characteristics of rotating machinery, static converters, power distribution systems and multi-phased circuits	Ref [1]
13-16	Student will demonstrate ability to use M&S application techniques that support military AC and DC motors and power distribution systems	Ref [1]
17-20	Student will demonstrate use of M&S tools to perform analysis and evaluation that support system trade off studies between AC and DC power distribution systems. This includes construction and operating characteristics of rotating machinery, static converters, power distribution systems and multi-phased circuits.	Ref [1]
21-24	Student will demonstrate use of M&S tools to perform analysis and evaluation that support military AC and DC power distribution system development. This includes construction and operating characteristics of rotating machinery, static	Ref [1]

Hours	ESR Syllabus	Ref
	converters, power distribution systems and multi-phased circuits.	

Ref [1] TBD by NPS Partners.

### **E10) C4ISR**

**Describe the basic components, methods and alternatives for transferring information from one point to another both internal and external to the system being considered. Evaluate available technologies for achieving rapid/effective/jam-resistant information transfer.**

- 1) Module name: C4ISR
- 2) Module coordinator: Marsha Taliaferro-Gillis, Ph.D.  
6596 Main Street  
Gloucester, VA 23061  
(804)694-3173 (Office)  
(804)824-4663 (Cell)  
mtgillis@werneranderson.com
- 3) Module description: C4ISR - Describe the basic components, methods and alternatives for transferring information from one point to another both internal and external to the system being considered. Evaluate available technologies for achieving rapid/effective/jam-resistant information transfer.
- 4) ESRs that the module supports: E10
- 5) Prerequisites assumed, and corresponding level of mastery:
- 6) Module maturity: none
- 7) Number of hours estimated to teach: 23
- 8) Proposed Delivery modality: face-to-face, on-line, VTC, resident, customer's site
- 9) Proposed references and texts:

*C4ISR/Sim Technical Reference Model Study Group Final Report (C4ISR/Sim TRM)*  
[www.sisostds.org](http://www.sisostds.org)

Daly, John J., Andreas Tolk. *Modeling and Simulation Integration with Network-Centric Command and Control Architectures*. 2003 Fall Simulation Interoperability Workshop. <http://bacon.gmu.edu/XMSF/pubs/03F-SIW-121.pdf>

Davis, Paul K. *Effects of Terrain, Maneuver Tactics, and C4ISR on the Effectiveness of Long-Range Precision Fires: A Stochastic Multiresolution Model (PEM) Calibrated to High-Resolution Simulation*. Santa Monica, CA: RAND, 2000.

Gonzales, Daniel, Louis R. Moore, Christopher G. Pernin, David M. Matonick, Paul Dreyer. *Assessing the Value of Information Superiority for Ground Forces-Proof of*

*Concept*. Santa Monica, CA: RAND: 2001. Retrieved October 19, 2007.  
[http://www.rand.org/pubs/documented\\_briefings/DB339/](http://www.rand.org/pubs/documented_briefings/DB339/)

Loughran, Julia. *Simulation Across The Spectrum: Less Is Sometimes More: How Distributed Games Can Be Used for Training and Analysis* September 2001, Retrieved October 29, 2007,  
[http://www.sisostds.org/webletter/siso/iss\\_78/art\\_379.htm](http://www.sisostds.org/webletter/siso/iss_78/art_379.htm)

Kossiakoff, Alexander; William N. Sweet. 2003 *Systems Engineering Principles and Practice*. Hoboken, NJ. John Wiley & Sons. Boston

Pace, Dale K. *Conceptual Model Development for C4ISR Simulations*, The Johns Hopkins University Applied Physics Laboratory. Retrieved October 29, 2007,  
[http://www.dodccrp.org/events/5th\\_ICCRTS/papers/Track2/059.pdf](http://www.dodccrp.org/events/5th_ICCRTS/papers/Track2/059.pdf)

10) Module learning objectives:

- E10.1 Identify key fundamental theoretical principles in C4ISR systems engineering
- E10.2 Describe the role and benefits of M&S in C4ISR systems engineering
- E10.3 Given a case study, understand key system characteristics of the C4ISR system of interest
- E10.4 Given a case study, identify the key elements of the C4ISR system to be modeled to meet the requirements of the specific use
- E10.5 Given a case study, apply or analyze the effectiveness of simulation tools used to evaluate the performance of the C4ISR system
- E10.6 Given a case study, apply or analyze key M&S issues related to interaction of subsystems within the C4ISR systems
- E10.7 Given a case study, analyze the VV&A implications of using a simulation of a C4ISR system given that is sufficiently different from its intended use
- E10.8 Given a case study, analyze whether the C4ISR system is modeled in sufficient detail to support program milestone decision requirements
- E10.9 Given a case study, analyze whether the C4ISR system is modeled in sufficient detail to support T&E requirements

11) Course assessment plan: projects, and exams

12) Topic list by hour of instruction and reference.

*Competency Level: General Awareness*

- i) Hour 1: Identify key fundamental theoretical principles in C4ISR systems engineering.
  - o Fundamental theoretical principles
  - o C4ISR systems engineering
  - o Systems Engineering and the World of Modern Systems, Kossiakoff Chapter 1

- (1) Kossiakoff, Alexander; William N. Sweet..2003.. *Systems Engineering Principles and Practice*. Hoboken, NJ: John Wiley & Sons. Boston
- (2) Daly, John J., Andreas Tolk. *Modeling and Simulation Integration with Network-Centric Command and Control Architectures*. 2003 Fall Simulation Interoperability Workshop. <http://bacon.gmu.edu/XMSF/pubs/03F-SIW-121.pdf>

*Competency Level: General Awareness*

- ii) Hour two: Identify key fundamental theoretical principles in C4ISR systems engineering.
  - Fundamental theoretical principles
  - C4ISR systems engineering
  - Systems Engineering and the World of Modern Systems, Kossiakoff Chapter 1
- (1) Kossiakoff, Alexander; William N. Sweet. 2003. *Systems Engineering Principles and Practice*. Hoboken, NJ: John Wiley & Sons. Boston.
- (2) Daly, John J., Andreas Tolk. *Modeling and Simulation Integration with Network-Centric Command and Control Architectures*. 2003 Fall Simulation Interoperability Workshop. <http://bacon.gmu.edu/XMSF/pubs/03F-SIW-121.pdf>

*Competency Level: General Awareness*

- iii) Hour 3: Describe the role and benefits of M&S in C4ISR systems engineering.
  - Roles and benefits of M&S
  - C4ISR systems engineering
  - Davis, Paul K. *Effects of Terrain, Maneuver Tactics, and C4ISR on the Effectiveness of Long-Range Precision Fires: A Stochastic Multiresolution Model (PEM) Calibrated to High-Resolution Simulation*. Santa Monica, CA: RAND, 2000.
  - Pace, Dale K. *Conceptual Model Development for C4ISR Simulations*, The Johns Hopkins University Applied Physics Laboratory. Retrieved October 29, 2007, [http://www.dodccrp.org/events/5th\\_ICCRTS/papers/Track2/059.pdf](http://www.dodccrp.org/events/5th_ICCRTS/papers/Track2/059.pdf)

*Competency Level: Understanding*

- iv) Hour four: Describe the role and benefits of M&S in C4ISR systems engineering.
  - Roles and benefits of M&S
  - C4ISR systems engineering



- Davis, Paul K. *Effects of Terrain, Maneuver Tactics, and C4ISR on the Effectiveness of Long-Range Precision Fires: A Stochastic Multiresolution Model (PEM) Calibrated to High-Resolution Simulation*. Santa Monica, CA: RAND, 2000.
- Pace, Dale K. *Conceptual Model Development for C4ISR Simulations*, The Johns Hopkins University Applied Physics Laboratory. Retrieved October 29, 2007, [http://www.dodccrp.org/events/5th\\_ICCRTS/papers/Track2/059.pdf](http://www.dodccrp.org/events/5th_ICCRTS/papers/Track2/059.pdf)

*Competency Level: General Awareness*

- v) Hour 5: Given a case study, understand key system characteristics of the C4ISR system of interest.

*Competency Level: Understanding*

- vi) Hour 6: Given a case study, understand key system characteristics of the C4ISR system of interest.

*Competency Level: Application*

- vii) Hour 7: Given a case study, identify the key elements of the C4ISR system to be modeled to meet the requirements of the specific use.
  - specific use

*Competency Level: Application*

- viii) Hour 8: Given a case study, identify the key elements of the C4ISR system to be modeled to meet the requirements of the specific use.
  - specific use

*Competency Level: Mastery*

- ix) Hour 9: Given a case study, identify the key elements of the C4ISR system to be modeled to meet the requirements of the specific use.
  - specific use

*Competency Level: Application*

- x) Hour 10: Given a case study, apply or analyze the effectiveness of simulation tools used to evaluate the performance of the C4ISR system.
  - effectiveness of simulation tools
- Gonzales, Daniel, Louis R. Moore, Christopher G. Pernin, David M. Matonick, Paul Dreyer. *Assessing the Value of Information Superiority for Ground Forces-Proof of Concept*. Santa Monica, CA: RAND: 2001. Retrieved October 19, 2007. [http://www.rand.org/pubs/documented\\_briefings/DB339/](http://www.rand.org/pubs/documented_briefings/DB339/)

*Competency Level: Application*

- xi) Hour 11: Given a case study, apply or analyze the effectiveness of simulation tools used to evaluate the performance of the C4ISR system.
  - effectiveness of simulation tools
  - Gonzales, Daniel, Louis R. Moore, Christopher G. Pernin, David M. Matonick, Paul Dreyer. *Assessing the Value of Information Superiority for Ground Forces-Proof of Concept*. Santa Monica, CA: RAND: 2001. Retrieved October 19, 2007.  
[http://www.rand.org/pubs/documented\\_briefings/DB339/](http://www.rand.org/pubs/documented_briefings/DB339/)

*Competency Level: Mastery*

- xii) Hour 12: Given a case study, apply or analyze the effectiveness of simulation tools used to evaluate the performance of the C4ISR system.
  - effectiveness of simulation tools
  - Gonzales, Daniel, Louis R. Moore, Christopher G. Pernin, David M. Matonick, Paul Dreyer. *Assessing the Value of Information Superiority for Ground Forces-Proof of Concept*. Santa Monica, CA: RAND: 2001. Retrieved October 19, 2007.  
[http://www.rand.org/pubs/documented\\_briefings/DB339/](http://www.rand.org/pubs/documented_briefings/DB339/)

*Competency Level: Application*

- xiii) Hour 13: Given a case study, apply or analyze key M&S issues related to interaction of subsystems within the C4ISR systems.
  - interaction of subsystems within C4ISR systems
  - Daly, John J., Andreas Tolk. *Modeling and Simulation Integration with Network-Centric Command and Control Architectures*. 2003 Fall Simulation Interoperability Workshop. <http://bacon.gmu.edu/XMSF/pubs/03F-SIW-121.pdf>

*Competency Level: Application*

- xiv) Hour 14: Given a case study, apply or analyze key M&S issues related to interaction of subsystems within the C4ISR systems.
  - interaction of subsystems within C4ISR systems
  - Daly, John J., Andreas Tolk. *Modeling and Simulation Integration with Network-Centric Command and Control Architectures*. 2003 Fall Simulation Interoperability Workshop. <http://bacon.gmu.edu/XMSF/pubs/03F-SIW-121.pdf>

*Competency Level: Understanding*

- xv) Hour 15: Given a case study, analyze the VV&A implications of using a simulation of a C4ISR system given that is sufficiently different from its intended use.

- VV&A
- VV&A Recommended Practices Guide

*Competency Level: Application*

- xvi) Hour 16: Given a case study, analyze the VV&A implications of using a simulation of a C4ISR system given that is sufficiently different from its intended use.

- VV&A
- VV&A Recommended Practices Guide

*Competency Level: Mastery*

- xvii) Hour 17: Given a case study, analyze the VV&A implications of using a simulation of a C4ISR system given that is sufficiently different from its intended use.

- VV&A
- VV&A Recommended Practices Guide

*Competency Level: Understanding*

- xviii) Hour 18: Given a case study, analyze whether the C4ISR system is modeled in sufficient detail to support program milestone decision requirements

- acquisition program milestone decision requirements
- CJCSI 3170.01
- DoD 5000.1, 5000.2

*Competency Level: Mastery*

- xix) Hour 19: Given a case study, analyze whether the C4ISR system is modeled in sufficient detail to support program milestone decision requirements.

- acquisition program milestone decision requirements
- CJCSI 3170.01
- DoD 5000.1, 5000.2

*Competency Level: Mastery*

- xx) Hour 20: Given a case study, analyze whether the C4ISR system is modeled in sufficient detail to support program milestone decision requirements

- acquisition program milestone decision requirements
- CJCSI 3170.01
- DoD 5000.1, 5000.2

*Competency Level: Understanding*

- xxi) Hour 21: Given a case study, analyze whether the C4ISR system is modeled in sufficient detail to support T&E requirements
  - C4ISR Test and Evaluation
  - modeling and Simulation to Support T&E
  - T&E Management Guide, Chapter 20
  - T&E Management Guide, Chapter 14

*Competency Level: Mastery*

- xxii) Hour 22: Given a case study, analyze whether the C4ISR system is modeled in sufficient detail to support T&E requirements
  - C4ISR Test and Evaluation
  - modeling and Simulation to Support T&E
  - T&E Management Guide, Chapter 20
  - T&E Management Guide, Chapter 14

*Competency Level: Mastery*

- xxiii) Hour 23: Given a case study, analyze whether the C4ISR system is modeled in sufficient detail to support T&E requirements
  - C4ISR Test and Evaluation
  - modeling and Simulation to Support T&E
  - T&E Management Guide, Chapter 20
  - T&E Management Guide, Chapter 14

### **E11) Networks**

**Describe the principles of networks applied to military applications including physical, command and control, and social networks and their implications for engineering design of systems.**

*Course Name:* Networks

*Course coordinator:*

Chris Ryder

MS 25-262

11100 Johns Hopkins Rd.

Laurel, MD 20723

*Course description:*

Describe the basic principles of communications networks used in military operations and on military systems that apply modeling and simulation as part of system verification, validation and test. Included in this course is assessing the integration of military systems into the Global Information Grid. Students will also model network topologies and parameters based on operational requirements

*Modules incorporated into Course:* E11

*ESRs that the course supports and corresponding level of mastery*

- 1 Key fundamental theoretical principles in systems engineering  
*Competency Level: General Awareness*
- 2 Role and benefits of M&S in systems engineering  
*Competency Level: General Awareness*
- 3 Key system characteristics of the system and component subsystems of interest  
*Competency Level: General Awareness*
- 4 Key elements of the system and component subsystem to be modeled to meet the requirements of the specific use  
*Competency Level: General Awareness*
- 5 Effectiveness of simulation tools used to evaluate the performance of the system and components subsystems  
*Competency Level: Application*
- 6 Role of component-based and distributed simulation as it applies to the system and component subsystems  
*Competency Level: Application*
- 7 M&S issues related to interaction of subsystems within a larger system

*Competency Level: Application*

- 8 VV&A implication of using a simulation of a system that is sufficiently different from its intended use

*Competency Level: Application*

- 9 Level of model detail for system and component subsystems to support program milestone decision requirements

*Competency Level: Mastery*

- 10 Level of model detail for system and component subsystems to support T&E requirements

*Competency Level: Mastery*

*Prerequisites assumed, and corresponding level of mastery:*

Understanding of military communications and their application.

*Course maturity: None*

*Number of contact hours and pace contemplated:*

- 14 three classroom hour sessions OR
- One 40 classroom hour short course OR
- This could also be broken up into two short courses
  - o Basic course consisting of modules E11.1 through E11.5 along with E11.9 and E11.10. (24 classroom hours)
  - o Advanced course would be a follow-on to the basic course. This which would include E11.6 through E11.8 (16 classroom hours).

*Proposed delivery methods:*

- This class is best suited for classroom environment where the students will have the ability to utilize a basic M&S application used for communications networks.
- An alternative would be for an online course in which an network related M&S application is integrated into the courseware

*Module learning objectives:*

E11.1 Provide a basic introduction of communications networks, including data and voice communications and military applications of networks.

E11.2 Provide and introduction of the types and usage of modeling and simulation for military systems that facilitates military data and voice communications  
(Prerequisite: E11.1 or appropriate knowledge)

- E11.3 Assess the impact of force structure and operational missions to communications requirements for military systems. Analyze requirements for network topologies, ports, parameters and information exchanges
- E11.4 Identify the use of M&S tools to simulate communications networks for military applications. (Prerequisite: E11.3 or appropriate knowledge)
- E11.5 Building operational scenarios and applying M&S tools and processes to determine predicted and actual network data loading and bandwidth demands. (Prerequisite: E11.4 or appropriate knowledge)
- E11.6 Design of network topology with appropriate data loading and bandwidth to accommodate operational scenarios. (Prerequisite: E11.5 or appropriate knowledge)
- E11.7 Hardware in the loop simulation of link and physical layers for communications equipment including routers, switches and radios (Prerequisite: E11.6 or appropriate knowledge)
- E11.8 Uses of M&S to assess network and transport layer communications protocols including broadcast and specific addressed messages. (Prerequisite: E11.6 or appropriate knowledge)
- E11.9 Discuss the utility of M&S for system communications and network integration to support program decisions
- E11.10 Discuss how M&S for system communications and network integration is used to support T&E requirements

*Course learning objectives:*

Understanding of integration of military systems with voice and data communications networks and how M&S is employed as a part of system verification, validation and test.

- This includes an understanding of communications network protocols including the Open Systems Institute (OSI) communications model and TCP/IP.
- Students will review how military operations correlate to communications requirements, including basic design of a communications network.
- Students will also gain insight into hardware in the loop simulation of the link and physical elements of communications networks as well as M&S applications for broadcast and addressed messages at the application and transport layers.
- Mastery to be demonstrated by a satisfactory score on unit quizzes and final project.

*Course assessment plan:*

- Satisfactory completion of course workbook and project material

## Topic list by hour of instruction and reference:

Session	Time	CL	Subject Area
1	4 Hours	GA	<p>Fundamentals of communications networks for voice and data communications. Topics include:</p> <ul style="list-style-type: none"> <li>• Open Systems Institute Architecture</li> <li>• TCP/IP</li> <li>• Analog and digital data transmissions</li> <li>• Transmission media</li> <li>• Data encoding</li> </ul>
2	2 Hours	GA	<p>Types and usage of M&amp;S for military systems that utilize voice and data communications. Topics include:</p> <ul style="list-style-type: none"> <li>• Campaign level M&amp;S <ul style="list-style-type: none"> <li>o Simulating the battlefield and its communications</li> </ul> </li> <li>• Mission level M&amp;S <ul style="list-style-type: none"> <li>o Simulating the “mission thread” for system under evaluation</li> </ul> </li> <li>• Engineering level M&amp;S <ul style="list-style-type: none"> <li>o Simulating technical properties of the weapon system and its communications subsystems</li> </ul> </li> </ul>
3	5 Hours	U	<p>Assess the impact of force structure and operational missions to communications requirements for military systems. This includes:</p> <ul style="list-style-type: none"> <li>• Understanding operational nodes, composition and location</li> <li>• Determination of missions to be performed with associated data elements and information exchanges</li> <li>• Evaluating the communication requirements to execute the operations</li> </ul> <p>Analyze requirements for network topologies, ports, parameters and information exchanges. This includes:</p> <ul style="list-style-type: none"> <li>• Introducing the concept of network and its related attributes that can meet the communications requirements</li> </ul>
4	4 Hours	U	<p>Identify the use of M&amp;S tools to simulate communications networks for military applications. This includes hands on use of an available M&amp;S tool and how that tool is utilized to develop a network and simulate it in the required environment.</p>
5	5 Hours	U	<p>Building operational scenarios and applying M&amp;S tools and processes to determine predicted and actual network data loading and bandwidth demands. This is a “hands on” exercise to apply the lesson learned in Session 3 using the tool introduced in Session 4.</p>
6	8 Hours	A	<p>Design a communications network based on the lessons learned in Sessions 4 and 5. Factor the data channels and pipelines with the required bandwidth.</p>
7	4	A	<p>Introduce the application of hardware in the loop simulation</p>



	Hours		for communications systems and subsystems over link and physical layers. Review the associated hardware elements used in HWIL.
8	4 Hours	A	Introduce the uses of M&S to evaluate communications over the network and transport layers of network. This includes use of addressed messages that go to a specific recipient as well as broadcast messages that are received by multiple addressees.
9	2 Hours	M	Present the uses of M&S in systems engineering of military systems and their communications subsystems in order to support program decisions. This includes cost, schedule and effectiveness of M&S in network systems engineering.
10	2 Hours	M	Present the uses of M&S for communications systems to support T&E requirements including establishing test cases, facility, equipment and personnel planning.

## Competency Levels:

GA = General Awareness

U = Understanding

A = Application

M = Mastery

## Proposed references and texts:

[1] Stallings, William; Data and Computer Communications; Prentice Hall, Upper Saddle River, NJ

## **E12) Environment**

**Describe the fundamentals of terrestrial science (geology, oceanography, meteorology, and near-earth space science) to represent how systems interact with and are influenced by their environment.**

- 1) Module name: The Environment
- 2) Module coordinator: Marsha Taliaferro-Gillis, Ph.D.  
6596 Main Street  
Gloucester, VA 23061  
(804)694-3173 (Office)  
(804)824-4663 (Cell)  
mtgillis@werneranderson.com
- 3) Module description: Describe the fundamentals of terrestrial science (geology, oceanography, meteorology, and near-earth space science) to represent how systems interact with and are influenced by their environment.
- 4) ESRs that the Module supports and corresponding level of mastery. E12
- 5) Prerequisites assumed, and corresponding level of mastery:
- 6) Module maturity: none
- 7) Number of hours estimated to teach 26
- 8) Proposed Delivery modality: face-to-face, on-line, VTC, resident, customer's site
- 9) Proposed references and texts:

Argent, Robert (2005). A Case Study of Environmental Modeling and Simulation Using Transplantable Components. Environmental Modeling & Software, 20(12), 1514-1523 Retrieved November 1, 2007 from [http://www.sciencedirect.com/science?\\_ob=ArticleURL&\\_udi=B6VHC-4GSBF5H-2&\\_...](http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6VHC-4GSBF5H-2&_...)

A case study of environmental modeling and simulation using transplantable components. Retrieved October 23, 2007 from [http://www.sciencedirect.com/science?\\_ob=ArticleURL&\\_udi=B6VHC-4GSBF5H-2&\\_...](http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6VHC-4GSBF5H-2&_...)

Atmospheric Science Department, UAH Courses. Retrieved October 23, 2007 from [http://www.nsstc.uah.edu/atmos/course\\_description\\_undergrad.html](http://www.nsstc.uah.edu/atmos/course_description_undergrad.html)

Best Practices – Modeling and Simulation Verification, Validation and Accreditation (VV&A) Guidebook. Retrieved October 23, 2007 from [http://www.drdc.gc.ca/seco/documents/VVA\\_Guidebookk\\_DND\\_SECO\\_May\\_2003\\_e.html](http://www.drdc.gc.ca/seco/documents/VVA_Guidebookk_DND_SECO_May_2003_e.html).

Final Precision Data Product Descriptions. Retrieved October 23, 2007 from [file:///C:/Documents and Settings/ntgillis/Desktop/htmlSNE\\_SRTM\\_Precision\\_Data.html](file:///C:/Documents%20and%20Settings/ntgillis/Desktop/htmlSNE_SRTM_Precision_Data.html).

Foundations for Verification and Validation of the Natural Environment in a Simulation. 2004. Retrieved October 23, 2007 from [wa.dmsi.mil/Special topics/Environment/environment.htm](http://wa.dmsi.mil/Special_topics/Environment/environment.htm)

Hargreaves, John. Keith..1992. *The Solar Terrestrial Environment: An Introduction to Geospace—Science*. Cambridge University Press. ISBN 0521427371

JSIMS Terrain Common Data Model, Revision 1.2a 27 July, 2007 Prepared by Lockheed Martin Information Systems Bellvue, WA. The MITRE Corporation McLean, VA, SAIC, Orlando, FL

Miller, Dale K., Kent Cauble, David Bakeman, Lockheed Martin Information Systems Advanced Simulation 3605 132<sup>nd</sup> Ave.SE, Suite 400, Bellvue, WA. 98—6,Center,Mark Torpey, Bill Helfinistine, Lockheed Martin Information Systems Advanced Simulation Center, 164 Middlesex Turnpike, Burlington, MA.,Andy Ceranowicz, Alion Science and Technology, P. O. Box 72, Stow. MA 01775, Extensions to the CTDB Format to Support Joint Experimentation. Retrieved from [ddmiller@lads.is.lmco.com](mailto:ddmiller@lads.is.lmco.com), [kcauble@lads.is.lmco.com](mailto:kcauble@lads.is.lmco.com),[dbakeman@lads.is.lmco.com](mailto:dbakeman@lads.is.lmco.com), [mtorpey@lads.is.lmc.ocom](mailto:mtorpey@lads.is.lmc.ocom), [bhelf@lads.is.lmco.com](mailto:bhelf@lads.is.lmco.com), [aceranowicz@alionscience.com](mailto:aceranowicz@alionscience.com).

National Geophysical Data Center (NGDC). Earth Observation Group. Retrieved October 23, 2007 from <http://www.ngdc.noaa.gov/dmsp/>

National Geophysical Data Center (NGDC). Geomagnetism. Retrieved October 23, 2007 from <http://www.ngdc.noaa.gov/seg/geomag/geomag.shtml>.

National Geophysical Data Center (NGDC). GOES Solar X-ray Imager. Retrieved October 23, w2007 from <http://sxi.ngdc.noaa.gov>

National Geophysical Data Center (NGDC). GOES Space Environment Monitor, Retrieved October 23, 2007 from <http://www/ngdc/noaa.gov/stp/GOES/goes.html>.

National Geophysical Data Center (NGDC). Ionosphere Data Archived at NGDC. Retrieved October 23, 2007 from <http://www.ngdc.noaa.gov/stp/IONO/ionohome.html>.

National Geophysical Data Center (NGDC). Land Geophysics. Retrieved October 23, 2007 from <http://www.ngdc.noaa.gov/seg/>

National Geophysical Data Center (NGDC). Links to Educational Resources in Oceanography and Earth Sciences. Retrieved October 23, 2007 from <http://www.ngdc.noaa.gov/mgg/education.html>.

National Geophysical Data Center (NGDC). Natural Hazards Data. Retrieved October 23, 2007 from <http://www.ngdc.noaa.gov/seg/hazard/hazards.shtml>

National Geophysical Data Center (NGDC). NOAA/POES Space Environment Monitor. Retrieved October 23, 2007 from [http://www.ngdc.noaa.gov/stp/NOAA/noaa\\_poes.html](http://www.ngdc.noaa.gov/stp/NOAA/noaa_poes.html).

National Geophysical Data Center (NGDC). Solar Data Services. Retrieved October 23, 2007 from <http://www.ngdc.noaa.gov/stp/SOLAR/solar.html>.

National Geophysical Data Center (NGDC). Welcome to SPIDR. Retrieved October 23, 2007 from <http://spidr.ngdc.noaa.gov/spidr/index.jsp>.

Richbourg, Robert, Institute for Defense Analysis. Digital Elevation Model Resolution and Simulated Natural Environment Terrain Representation Fidelity. Retrieved November 1, 2007 from [www.sisostds.org/index.php?tg=articles&idx=More&article=45&article203-24k](http://www.sisostds.org/index.php?tg=articles&idx=More&article=45&article203-24k)

Stevens, Clark D., Brett Butler, Charles Campbell, Jon Watkins, Eric Root, Henry Marshall, Teresita Sotomayor. A Common Runtime Format for Virtual and Constructive Simulations. Retrieved October 23, 2007 from [file:///C:/Documents and Settings/mtgillis/Desktop/htmlSNE\\_SRTM\\_Precision\\_Data.html](file:///C:/Documents%20and%20Settings/mtgillis/Desktop/htmlSNE_SRTM_Precision_Data.html).

Stevens, Clark D., Dale D., Miller, Steve Prager, Charles Campbell, Jon Watkins, Eric Root, James Oneal. Data Modeling Implications for a Data Driven Environmental Software Sub-System. Retrieved October 23, 2007 from [file:///C:/Documents and Settings/mtgillis/Desktop/htmlSNE\\_SRTM\\_Precision\\_Data.html](file:///C:/Documents%20and%20Settings/mtgillis/Desktop/htmlSNE_SRTM_Precision_Data.html).

Stevens, Clark D.(2000). Toward a Common Synthetic Natural Environment. Retrieved October 23, 2007 from [file:///C:/Documents and Settings/mtgillis/Desktop/htmlSNE\\_SRTM\\_Precision\\_Data.html](file:///C:/Documents%20and%20Settings/mtgillis/Desktop/htmlSNE_SRTM_Precision_Data.html).

SAIC: Space: Space, Earth, and Atmospheric Sciences. Retrieved October 23, 2007 from <http://www.saic.com/space/earth.html>.

Triangulated Irregular Network (TIN) Tutorial. Retrieved October 23, 2007 from [file:///C:/Documents and Settings/mtgillis/Desktop/html/SNE\\_TIN/html](file:///C:/Documents and Settings/mtgillis/Desktop/html/SNE_TIN/html)

Twicken, Joe. Fundamentals of Atmospheres, Weather and Climate. Retrieved October 23, 2007 from [http://resources.yesican-science.ca/trek/mars/lander/mgs\\_atmos10.htm](http://resources.yesican-science.ca/trek/mars/lander/mgs_atmos10.htm).

Stevens, Clark D., Brett Butler, Charles Campbell, Jon Watkins, Eric Root, Henry Marshall, Teresita Sotomayor. A Common Runtime Format for Virtual and Constructive Simulations. Retrieved October 23, 2007 from [file:///C:/Documents and Settings/ntgillis/Desktop/html/SNE\\_SRTM\\_Precision\\_Data.html](file:///C:/Documents and Settings/ntgillis/Desktop/html/SNE_SRTM_Precision_Data.html).

10) Module learning objectives:

- E12.1 Given a case study, understand key fundamental theoretical principles in terrestrial science as they apply to the system of interest.
- E12.2 Given a case study, understand key system characteristics of the system of interest.
- E12.3 Given a case study, identify the key elements of the environment to be modeled to meet the requirements of the specific use.
- E12.4 Given a case study, apply or analyze the effectiveness of simulation tools used evaluate the performance of the system of interest in the environment.
- E12.5 Given a case study, apply or analyze key M&S issues related to interaction of the system of interest with the environment (terrain database compatibility, line-of-sight, weather,).
- E12.6 Given a case study, analyze the VV&A implications of using a simulation in an environment that is sufficiently different from its intended use.
- E12.7 Given a case study, analyze if the environmental factors are modeled in sufficient detail to support program milestone decision requirements.
- E12.8 Given a case study, analyze if the environmental factors are modeled in sufficient detail to support T&E requirements.

11) Module assessment plan: projects, and exams

12) Topic list by hour of instruction and reference.

*Competency Level: General Awareness*

- i) Hour 1: Given a case study, understand key fundamental theoretical principles in terrestrial science as they apply to the system of interest.
  - fundamental theoretical l principles
  - terrestrial science
  - Atmospheric Science Department, UAH Courses. Retrieved October 23, 2007 from [http://www.nsstc.uah.edu/atmos/course\\_description\\_undergrad.html](http://www.nsstc.uah.edu/atmos/course_description_undergrad.html)

- Hargreaves, John. Keith..1992. *The Solar Terrestrial Environment: An Introduction to Geospace—Science*. Cambridge University Press. ISBN 0521427371
- National Geophysical Data Center (NGDC). Solar Data Services. Retrieved October 23, 2007 from <http://www.ngdc.noaa.gov/stp/SOLAR/solar.html>.
- National Geophysical Data Center (NGDC). Welcome to SPIDR. Retrieved October 23, 2007 from <http://spidr.ngdc.noaa.gov/spidr/index.jsp>.
- SAIC: Space: Space, Earth, and Atmospheric Sciences. Retrieved October 23, 2007 from <http://www.saic.com/space/earth.html>.
- Twicken, Joe. Fundamentals of Atmospheres, Weather and Climate. Retrieved October 23, 2007 from [http://resources.yesican-science.ca/trek/mars/lander/mgs\\_atmos10.htm](http://resources.yesican-science.ca/trek/mars/lander/mgs_atmos10.htm).

*Competency Level: Understanding*

- ii) Hour 2: Given a case study, understand key fundamental theoretical principles in terrestrial science as they apply to the system of interest.
  - fundamental theoretical principles
  - terrestrial science
- Atmospheric Science Department, UAH Courses. Retrieved October 23, 2007 from [http://www.nsstc.uah.edu/atmos/coursedescription\\_undergrad.html](http://www.nsstc.uah.edu/atmos/coursedescription_undergrad.html)
- Hargreaves, John. Keith..1992. *The Solar Terrestrial Environment: An Introduction to Geospace—Science*. Cambridge University Press. ISBN 0521427371
- National Geophysical Data Center (NGDC). Solar Data Services. Retrieved October 23, 2007 from <http://www.ngdc.noaa.gov/stp/SOLAR/solar.html>.
- National Geophysical Data Center (NGDC). Welcome to SPIDR. Retrieved October 23, 2007 from <http://spidr.ngdc.noaa.gov/spidr/index.jsp>.
- SAIC: Space: Space, Earth, and Atmospheric Sciences. Retrieved October 23, 2007 from <http://www.saic.com/space/earth.html>.
- Twicken, Joe. Fundamentals of Atmospheres, Weather and Climate. Retrieved October 23, 2007 from [http://resources.yesican-science.ca/trek/mars/lander/mgs\\_atmos10.htm](http://resources.yesican-science.ca/trek/mars/lander/mgs_atmos10.htm).

*Competency Level: Understanding*

- iii) Hour 3: Given a case study, understand key fundamental theoretical principles in terrestrial science as they apply to the system of interest.
- fundamental theoretical principles
  - terrestrial science
  - Atmospheric Science Department, UAH Courses. Retrieved October 23, 2007 from [http://www.nsstc.uah.edu/atmos/coursedescription\\_undergrad.html](http://www.nsstc.uah.edu/atmos/coursedescription_undergrad.html)
  - Hargreaves, John. Keith..1992. *The Solar Terrestrial Environment: An Introduction to Geospace—Science*. Cambridge University Press. ISBN 0521427371
  - National Geophysical Data Center (NGDC). Solar Data Services. Retrieved October 23, 2007 from <http://www.ngdc.noaa.gov/stp/SOLAR/solar.html>.
  - National Geophysical Data Center (NGDC). Welcome to SPIDR. Retrieved October 23, 2007 from <http://spidr.ngdc.noaa.gov/spidr/index.jsp>.
  - SAIC: Space: Space, Earth, and Atmospheric Sciences. Retrieved October 23, 2007 from <http://www.saic.com/space/earth.html>.
  - Twicken, Joe. Fundamentals of Atmospheres, Weather and Climate. Retrieved October 23, 2007 from [http://resources.yesican-science.ca/trek/mars/lander/mgs\\_atmos10.htm](http://resources.yesican-science.ca/trek/mars/lander/mgs_atmos10.htm).

*Competency Level: General Awareness*

- iv) Hour 4: Given a case study, understand key system characteristics of the system of interest
- key characteristics
  - system of interest
  - Atmospheric Science Department, UAH Courses. Retrieved October 23, 2007 from [http://www.nsstc.uah.edu/atmos/coursedescription\\_undergrad.html](http://www.nsstc.uah.edu/atmos/coursedescription_undergrad.html)
  - JSIMS Terrain Common Data Model, Revision 1.2a 27 July, 2007 Prepared by Lockheed Martin Information Systems Bellvue, WA. The MITRE Corporation McLean, VA, SAIC, Orlando, FL

*Competency Level: Understanding*

- v) Hour 5: Given a case study, understand key system characteristics of the system of interest

- key characteristics
- system interest
- Atmospheric Science Department, UAH Courses. Retrieved October 23, 2007 from [http://www.nsstc.uah.edu/atmos/course\\_description\\_undergrad.html](http://www.nsstc.uah.edu/atmos/course_description_undergrad.html)
- JSIMS Terrain Common Data Model, Revision 1.2a 27 July, 2007 Prepared by Lockheed Martin Information Systems Bellvue, WA. The MITRE Corporation McLean, VA, SAIC, Orlando, FL

*Competency Level: General Awareness*

- vi) Hour 6: Given a case study, identify the key elements of the environment to be modeled to meet the requirements of the specific use.
- key elements of modeled environments
  - requirements of specific use
  - National Geophysical Data Center (NGDC). Earth Observation Group. Retrieved October 23, 2007 from <http://www.ngdc.noaa.gov/dmsp/>
  - National Geophysical Data Center (NGDC). Geomagnetism. Retrieved October 23, 2007 from <http://www.ngdc.noaa.gov/seg/geomag/geomag.shtml>.
  - National Geophysical Data Center (NGDC). GOES Solar X-ray Imager. Retrieved October 23, 2007 from <http://sxi.ngdc.noaa.gov>
  - National Geophysical Data Center (NGDC). GOES Space Environment Monitor, Retrieved October 23, 2007 from <http://www.ngdc.noaa.gov/stp/GOES/goes.html>.
  - National Geophysical Data Center (NGDC). Ionosphere Data Archived at NGDC. Retrieved October 23, 2007 from <http://www.ngdc.noaa.gov/stp/IONO/ionohome.html>.
  - National Geophysical Data Center (NGDC). Land Geophysics. Retrieved October 23, 2007 from <http://www.ngdc.noaa.gov/seg/>
  - National Geophysical Data Center (NGDC). Links to Educational Resources in Oceanography and Earth Sciences. Retrieved October 23, 2007 from <http://www.ngdc.noaa.gov/mgg/education.html>.
  - National Geophysical Data Center (NGDC). Natural Hazards Data. Retrieved October 23, 2007 from <http://www.ngdc.noaa.gov/seg/hazard/hazards.shtml>
  - National Geophysical Data Center (NGDC). NOAA/POES Space Environment Monitor. Retrieved October 23, 2007 from [http://www.ngdc.noaa.gov/stp/NOAA/noaa\\_poes.html](http://www.ngdc.noaa.gov/stp/NOAA/noaa_poes.html).



*Competency Level: General Awareness*

- vii) Hour 7: Given a case study, identify the key elements of the environment to be modeled to meet the requirements of the specific use.
- key elements of modeled environments
  - requirements of specific use
  - National Geophysical Data Center (NGDC). Earth Observation Group. Retrieved October 23, 2007 from <http://www.ngdc.noaa.gov/dmsp/>
  - National Geophysical Data Center (NGDC). Geomagnetism. Retrieved October 23, 2007 from <http://www.ngdc.noaa.gov/seg/geomag/geomag.shtml>.
  - National Geophysical Data Center (NGDC). GOES Solar X-ray Imager. Retrieved October 23, 2007 from <http://sxi.ngdc.noaa.gov>
  - National Geophysical Data Center (NGDC). GOES Space Environment Monitor, Retrieved October 23, 2007 from <http://www.ngdc.noaa.gov/stp/GOES/goes.html>.
  - National Geophysical Data Center (NGDC). Ionosphere Data Archived at NGDC. Retrieved October 23, 2007 from <http://www.ngdc.noaa.gov/stp/IONO/ionohome.html>.
  - National Geophysical Data Center (NGDC). Land Geophysics. Retrieved October 23, 2007 from <http://www.ngdc.noaa.gov/seg/>
  - National Geophysical Data Center (NGDC). Links to Educational Resources in Oceanography and Earth Sciences. Retrieved October 23, 2007 from <http://www.ngdc.noaa.gov/mgg/education.html>.
  - National Geophysical Data Center (NGDC). Natural Hazards Data. Retrieved October 23, 2007 from <http://www.ngdc.noaa.gov/seg/hazard/hazards.shtml>
  - National Geophysical Data Center (NGDC). NOAA/POES Space Environment Monitor. Retrieved October 23, 2007 from [http://www.ngdc.noaa.gov/stp/NOAA/noaa\\_poes.html](http://www.ngdc.noaa.gov/stp/NOAA/noaa_poes.html).

*Competency Level: General Awareness*

- viii) Hour 8: Given a case study, apply or analyze the effectiveness of simulation tools used to evaluate the performance of the system of interest in the environment.
- application and analysis
  - effectiveness of simulation tools
  - performance of system in environment
  - Argent, Robert (2005). A Case Study of Environmental Modeling and Simulation Using Transplantable Components. Environmental Modeling & Software,

20(12), 1514-1523 Retrieved November 1, 2007 from [http://www.sciencedirect.com/science?\\_ob=ArticleURL&\\_udi=B6VHC-4GSBFSH-2&\\_....](http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6VHC-4GSBFSH-2&_....)

- Miller, Dale K., Kent Cauble, David Bakeman, Lockheed Martin Information Systems Advanced Simulation 3605 132<sup>nd</sup> Ave. SE, Suite 400, Bellevue, WA. 98—6, Center, Mark Torpey, Bill Helfinistine, Lockheed Martin Information Systems Advanced Simulation Center, 164 Middlesex Turnpike, Burlington, MA., Andy Ceranowicz, Alion Science and Technology, P. O. Box 72, Stow. MA 01775, Extensions to the CTDB Format to Support Joint Experimentation. Retrieved from [ddmiller@lads.is.lmco.com](mailto:ddmiller@lads.is.lmco.com), [kcauble@lads.is.lmco.com](mailto:kcauble@lads.is.lmco.com), [dbakeman@lads.is.lmco.com](mailto:dbakeman@lads.is.lmco.com), [mtorpey@lads.is.lmc.ocom](mailto:mtorpey@lads.is.lmc.ocom), [bhelf@lads.is.lmco.com](mailto:bhelf@lads.is.lmco.com), [aceranowicz@alionscience.com](mailto:aceranowicz@alionscience.com).
- Stevens, Clark D. (2000). Toward a Common Synthetic Natural Environment. Retrieved October 23, 2007 from [file:///C:/Documents and Settings/mtgillis/Desktop/htmlSNE\\_SRTM\\_Precision Data.html](file:///C:/Documents%20and%20Settings/mtgillis/Desktop/htmlSNE_SRTM_Precision_Data.html)

*Competency Level: Understanding*

- ix) Hour 9: Given a case study, apply or analyze the effectiveness of simulation tools used to evaluate the performance of the system of interest in the environment.
- application and analysis
  - effectiveness of simulation tools
  - performance of system in environment
  - Argent, Robert (2005). A Case Study of Environmental Modeling and Simulation Using Transplantable Components. Environmental Modeling & Software, 20(12), 1514-1523 Retrieved November 1, 2007 from [http://www.sciencedirect.com/science?\\_ob=ArticleURL&\\_udi=B6VHC-4GSBFSH-2&\\_....](http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6VHC-4GSBFSH-2&_....)
  - Miller, Dale K., Kent Cauble, David Bakeman, Lockheed Martin Information Systems Advanced Simulation 3605 132<sup>nd</sup> Ave. SE, Suite 400, Bellevue, WA. 98—6, Center, Mark Torpey, Bill Helfinistine, Lockheed Martin Information Systems Advanced Simulation Center, 164 Middlesex Turnpike, Burlington, MA., Andy Ceranowicz, Alion Science and Technology, P. O. Box 72, Stow. MA 01775, Extensions to the CTDB Format to Support Joint Experimentation. Retrieved from [ddmiller@lads.is.lmco.com](mailto:ddmiller@lads.is.lmco.com), [kcauble@lads.is.lmco.com](mailto:kcauble@lads.is.lmco.com), [dbakeman@lads.is.lmco.com](mailto:dbakeman@lads.is.lmco.com),

[mtorpey@lads.is.lmc.ocom](mailto:mtorpey@lads.is.lmc.ocom), [bhelf@lads.is.lmco.com](mailto:bhelf@lads.is.lmco.com),  
[aceranowicz@alionscience.com](mailto:aceranowicz@alionscience.com).

- Stevens, Clark D.(2000). Toward a Common Synthetic Natural Environment. Retrieved October 23, 2007 from [file:///C:/Documents and Settings/mtgillis/Desktop/htmlSNE\\_SRTM\\_Precision Data.html](file:///C:/Documents%20and%20Settings/mtgillis/Desktop/htmlSNE_SRTM_Precision_Data.html)

*Competency Level: Application*

- x) Hour 10: Given a case study, apply or analyze the effectiveness of simulation tools used to evaluate the performance of the system of interest in the environment.
  - application and analysis
  - effectiveness of simulation tools
  - performance of system in environment
- Argent, Robert (2005). A Case Study of Environmental Modeling and Simulation Using Transplantable Components. Environmental Modeling & Software, 20(12), 1514-1523 Retrieved November 1, 2007 from [http://www.sciencedirect.com/science?\\_ob=ArticleURL&\\_udi=B6VHC-4GSBFSH-2&\\_....](http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6VHC-4GSBFSH-2&_....)
- Miller, Dale K., Kent Cauble, David Bakeman, Lockheed Martin Information Systems Advanced Simulation 3605 132<sup>nd</sup> Ave.SE, Suite 400, Bellvue, WA. 98—6,Center,Mark Torpey, Bill Helfinistine, Lockheed Martin Information Systems Advanced Simulation Center, 164 Middlesex Turnpike, Burlington, MA.,Andy Ceranowicz, Alion Science and Technology, P. O. Box 72, Stow. MA 01775, Extensions to the CTDB Format to Support Joint Experimentation. Retrieved from [ddmiller@lads.is.lmco.com](mailto:ddmiller@lads.is.lmco.com), [kcauble@lads.is.lmco.com](mailto:kcauble@lads.is.lmco.com),[dbakeman@lads.is.lmco.com](mailto:dbakeman@lads.is.lmco.com), [mtorpey@lads.is.lmc.ocom](mailto:mtorpey@lads.is.lmc.ocom), [bhelf@lads.is.lmco.com](mailto:bhelf@lads.is.lmco.com), [aceranowicz@alionscience.com](mailto:aceranowicz@alionscience.com).
- Stevens, Clark D.(2000). Toward a Common Synthetic Natural Environment. Retrieved October 23, 2007 from [file:///C:/Documents and Settings/mtgillis/Desktop/htmlSNE\\_SRTM\\_Precision Data.html](file:///C:/Documents%20and%20Settings/mtgillis/Desktop/htmlSNE_SRTM_Precision_Data.html)

*Competency Level: Application*

- xi) Hour 11: Given a case study, apply or analyze the effectiveness of simulation tools used to evaluate the performance of the system of interest in the environment.
  - application and analysis
  - effectiveness of simulation tools

- performance of system in environment
- Argent, Robert (2005). A Case Study of Environmental Modeling and Simulation Using Transplantable Components. *Environmental Modeling & Software*, 20(12), 1514-1523 Retrieved November 1, 2007 from [http://www.sciencedirect.com/science?\\_ob=ArticleURL&\\_udi=B6VHC-4GSBFSH-2&\\_....](http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6VHC-4GSBFSH-2&_....)
- Miller, Dale K., Kent Cauble, David Bakeman, Lockheed Martin Information Systems Advanced Simulation 3605 132<sup>nd</sup> Ave.SE, Suite 400, Bellvue, WA. 98—6,Center,Mark Torpey, Bill Helfinistine, Lockheed Martin Information Systems Advanced Simulation Center, 164 Middlesex Turnpike, Burlington, MA.,Andy Ceranowicz, Alion Science and Technology, P. O. Box 72, Stow. MA 01775, Extensions to the CTDB Format to Support Joint Experimentation. Retrieved from [ddmiller@lads.is.lmco.com](mailto:ddmiller@lads.is.lmco.com), [kcauble@lads.is.lmco.com](mailto:kcauble@lads.is.lmco.com), [dbakeman@lads.is.lmco.com](mailto:dbakeman@lads.is.lmco.com), [mtorpey@lads.is.lmc.ocom](mailto:mtorpey@lads.is.lmc.ocom), [bhelf@lads.is.lmco.com](mailto:bhelf@lads.is.lmco.com), [aceranowicz@alionscience.com](mailto:aceranowicz@alionscience.com).
- Stevens, Clark D.(2000). Toward a Common Synthetic Natural Environment. Retrieved October 23, 2007 from [file:///C:/Documents and Settings/mtgillis/Desktop/htmlSNE\\_SRTM\\_Precision Data.html](file:///C:/Documents%20and%20Settings/mtgillis/Desktop/htmlSNE_SRTM_Precision_Data.html)

*Competency Level: Mastery*

- xii) Hour 12: Given a case study, apply or analyze the effectiveness of simulation tools used to evaluate the performance of the system of interest in the environment.
- application and analysis
  - effectiveness of simulation tools
  - performance of system in environment
  - Argent, Robert (2005). A Case Study of Environmental Modeling and Simulation Using Transplantable Components. *Environmental Modeling & Software*, 20(12), 1514-1523 Retrieved November 1, 2007 from [http://www.sciencedirect.com/science?\\_ob=ArticleURL&\\_udi=B6VHC-4GSBFSH-2&\\_....](http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6VHC-4GSBFSH-2&_....)
  - Miller, Dale K., Kent Cauble, David Bakeman, Lockheed Martin Information Systems Advanced Simulation 3605 132<sup>nd</sup> Ave.SE, Suite 400, Bellvue, WA. 98—6,Center,Mark Torpey, Bill Helfinistine, Lockheed Martin Information Systems Advanced Simulation Center, 164 Middlesex Turnpike, Burlington, MA.,Andy Ceranowicz, Alion Science and Technology, P. O. Box 72, Stow. MA 01775,

Extensions to the CTDB Format to Support Joint Experimentation. Retrieved from [ddmiller@lads.is.lmco.com](mailto:ddmiller@lads.is.lmco.com), [kcauble@lads.is.lmco.com](mailto:kcauble@lads.is.lmco.com), [dbakeman@lads.is.lmco.com](mailto:dbakeman@lads.is.lmco.com), [mtorpey@lads.is.lmc.ocom](mailto:mtorpey@lads.is.lmc.ocom), [bhelf@lads.is.lmco.com](mailto:bhelf@lads.is.lmco.com), [aceranowicz@alionscience.com](mailto:aceranowicz@alionscience.com).

- Stevens, Clark D.(2000). Toward a Common Synthetic Natural Environment. Retrieved October 23, 2007 from [file:///C:/Documents and Settings\mtgillis\Desktop\htmlSNE\\_SRTM\\_Precision Data.html](file:///C:/Documents%20and%20Settings/mtgillis/Desktop/htmlSNE_SRTM_Precision_Data.html)

*Competency Level: General Awareness*

- xiii) Hour 13: Given a case study, apply or analyze key M&S issues related to interaction of the system of interest with the environment (terrain database compatibility, line-of-sight, weather,).
  - application and analysis of M&S issues
  - system interactions with environment
  - terrain, database, compatibility, line of sight. and weather
- Hargreaves, John. Keith..1992. *The Solar Terrestrial Environment: An Introduction to Geospace—Science*. Cambridge University Press. ISBN 0521427371
- SAIC: Space: Space, Earth, and Atmospheric Sciences. Retrieved October 23, 2007 from <http://www.saic.com/space/earth.html>.
- Stevens, Clark D.(2000). Toward a Common Synthetic Natural Environment. Retrieved October 23, 2007 from [file:///C:/Documents and Settings\ntgillis\Desktop\htmlSNE\\_SRTM\\_Precision Data.html](file:///C:/Documents%20and%20Settings/ntgillis/Desktop/htmlSNE_SRTM_Precision_Data.html)
- Triangulated Irregular Network (TIN) Tutorial. Retrieved October 23, 2007 from [file:///C:/Documents and Settings\mtgillis\Desktop\html\SNE\\_TIN/html](file:///C:/Documents%20and%20Settings/mtgillis/Desktop/html/SNE_TIN/html)
- Twicken, Joe. Fundamentals of Atmospheres, Weather and Climate. Retrieved October 23, 2007 from [http://resources.yesican-science.ca/trek/mars/lander/mgs\\_atmos10.htm](http://resources.yesican-science.ca/trek/mars/lander/mgs_atmos10.htm).

*Competency Level: Understanding*

- xiv) Hour 14: Given a case study, apply or analyze key M&S issues related to interaction of the system of interest with the environment (terrain database compatibility, line-of-sight, weather,).
  - application and analysis of M&S issues
  - system interactions with environment

- terrain, database, compatibility, line of sight. and weather
- Hargreaves, John. Keith..1992. *The Solar Terrestrial Environment: An Introduction to Geospace—Science*. Cambridge University Press. ISBN 0521427371
- SAIC: Space: Space, Earth, and Atmospheric Sciences. Retrieved October 23, 2007 from <http://www.saic.com/space/earth.html>.
- Stevens, Clark D.(2000). Toward a Common Synthetic Natural Environment. Retrieved October 23, 2007 from [file:///C:/Documents and Settings/mtgillis/Desktop/htmlSNE\\_SRTM\\_Precision\\_Data.html](file:///C:/Documents and Settings/mtgillis/Desktop/htmlSNE_SRTM_Precision_Data.html)
- Triangulated Irregular Network (TIN) Tutorial. Retrieved October 23, 2007 from [file:///C:/Documents and Settings/mtgillis/Desktop/html/SNE\\_TIN/html](file:///C:/Documents and Settings/mtgillis/Desktop/html/SNE_TIN/html)
- Twicken, Joe. Fundamentals of Atmospheres, Weather and Climate. Retrieved October 23, 2007 from [http://resources.yesican-science.ca/trek/mars/lander/mgs\\_atmos10.htm](http://resources.yesican-science.ca/trek/mars/lander/mgs_atmos10.htm).

*Competency Level: Application*

- xv) Hour 15: Given a case study, apply or analyze key M&S issues related to interaction of the system of interest with the environment (terrain database compatibility, line-of-sight, weather,).
- application and analysis of M&S issues
  - system interactions with environment
  - terrain, database, compatibility, line of sight. and weather
  - Hargreaves, John. Keith..1992. *The Solar Terrestrial Environment: An Introduction to Geospace—Science*. Cambridge University Press. ISBN 0521427371
  - SAIC: Space: Space, Earth, and Atmospheric Sciences. Retrieved October 23, 2007 from <http://www.saic.com/space/earth.html>.
  - Stevens, Clark D.(2000). Toward a Common Synthetic Natural Environment. Retrieved October 23, 2007 from [file:///C:/Documents and Settings/mtgillis/Desktop/htmlSNE\\_SRTM\\_Precision\\_Data.html](file:///C:/Documents and Settings/mtgillis/Desktop/htmlSNE_SRTM_Precision_Data.html)
  - Triangulated Irregular Network (TIN) Tutorial. Retrieved October 23, 2007 from [file:///C:/Documents and Settings/mtgillis/Desktop/html/SNE\\_TIN/html](file:///C:/Documents and Settings/mtgillis/Desktop/html/SNE_TIN/html)
  - Twicken, Joe. Fundamentals of Atmospheres, Weather and Climate. Retrieved October 23, 2007 from

[http://resources.yesican-science.ca/trek/mars/lander/mgs\\_atmos10.htm](http://resources.yesican-science.ca/trek/mars/lander/mgs_atmos10.htm).

*Competency Level: Application*

- xvi) Hour 16: Given a case study, apply or analyze key M&S issues related to interaction of the system of interest with the environment (terrain database compatibility, line-of-sight, weather,).
- application and analysis of M&S issues
  - system interactions with environment
  - terrain, database, compatibility, line of sight. and weather
- Hargreaves, John. Keith..1992. *The Solar Terrestrial Environment: An Introduction to Geospace—Science*. Cambridge University Press. ISBN 0521427371
  - SAIC: Space: Space, Earth, and Atmospheric Sciences. Retrieved October 23, 2007 from <http://www.saic.com/space/earth.html>.
  - Stevens, Clark D.(2000). Toward a Common Synthetic Natural Environment. Retrieved October 23, 2007 from [file:///C:/Documents and Settings/ntgillis/Desktop/html/SNE\\_SRTM\\_Precision\\_Data.html](file:///C:/Documents and Settings/ntgillis/Desktop/html/SNE_SRTM_Precision_Data.html)
  - Triangulated Irregular Network (TIN) Tutorial. Retrieved October 23, 2007 from [file:///C:/Documents and Settings/ntgillis/Desktop/html/SNE\\_TIN/html](file:///C:/Documents and Settings/ntgillis/Desktop/html/SNE_TIN/html)
  - Twicken, Joe. Fundamentals of Atmospheres, Weather and Climate..Retrieved October 23, 2007 from [http://resources.yesican-science.ca/trek/mars/lander/mgs\\_atmos10.htm](http://resources.yesican-science.ca/trek/mars/lander/mgs_atmos10.htm).

*Competency Level: Mastery*

- xvii) Hour 17: :Given a case study, apply or analyze key M&S issues related to interaction of the system of interest with the environment (terrain database compatibility, line-of-sight, weather,).
- application and analysis of M&S issues
  - system interactions with environment
  - terrain, database, compatibility, line of sight. and weather
- Hargreaves, John. Keith..1992. *The Solar Terrestrial Environment: An Introduction to Geospace—Science*. Cambridge University Press. ISBN 0521427371
  - SAIC: Space: Space, Earth, and Atmospheric Sciences. Retrieved October 23, 2007 from <http://www.saic.com/space/earth.html>.
  - Stevens, Clark D.(2000). Toward a Common Synthetic Natural Environment. Retrieved October 23, 2007 from



[file:///C:/Documents and Settings/mtgillis/Desktop/htmlSNE\\_SRTM\\_Precision\\_Data.html](file:///C:/Documents%20and%20Settings/mtgillis/Desktop/htmlSNE_SRTM_Precision_Data.html)

- Triangulated Irregular Network (TIN) Tutorial. Retrieved October 23, 2007 from [file:///C:/Documents and Settings/mtgillis/Desktop/html/SNE\\_TIN/html](file:///C:/Documents%20and%20Settings/mtgillis/Desktop/html/SNE_TIN/html)
- Twicken, Joe. Fundamentals of Atmospheres, Weather and Climate. Retrieved October 23, 2007 from [http://resources.yesican-science.ca/trek/mars/lander/mgs\\_atmos10.htm](http://resources.yesican-science.ca/trek/mars/lander/mgs_atmos10.htm).

*Competency Level: Mastery*

xviii) Hour 18: Given a case study, analyze the VV&A implications of using a simulation in an environment that is sufficiently different from its intended use.

- VV&A analysis of environmental simulation
- VV&A analysis of environmental simulation different from intended use
- Argent, Robert (2005). A Case Study of Environmental Modeling and Simulation Using Transplantable Components. Environmental Modeling & Software, 20(12), 1514-1523 Retrieved November 1, 2007 from [http://www.sciencedirect.com/science?\\_ob=ArticleURL&\\_udi=B6VHC-4GSBFSH-2& ...](http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6VHC-4GSBFSH-2&...)
- Foundations for Verification and Validation of the Natural Environment in a Simulation. 2004. Retrieved October 23, 2007 from [wa.dmsomil/Special topics/Environment/environment.hrm](http://wa.dmsomil/Specialtopics/Environment/environment.hrm)

*Competency Level: Mastery*

xix) Hour 19: Given a case study, analyze the VV&A implications of using a simulation in an environment that is sufficiently different from its intended use.

- VV&A analysis of environmental simulation
- VV&A analysis of environmental simulation different from intended use
- Argent, Robert (2005). A Case Study of Environmental Modeling and Simulation Using Transplantable Components. Environmental Modeling & Software, 20(12), 1514-1523 Retrieved November 1, 2007 from [http://www.sciencedirect.com/science?\\_ob=ArticleURL&\\_udi=B6VHC-4GSBFSH-2& ...](http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6VHC-4GSBFSH-2&...)
- Foundations for Verification and Validation of the Natural Environment in a Simulation. 2004. Retrieved October 23, 2007 from [wa.dmsomil/Special topics/Environment/environment.hrm](http://wa.dmsomil/Specialtopics/Environment/environment.hrm)



*Competency Level: Mastery*

- xx) Hour 20: Given a case study, analyze the VV&A implications of using a simulation in an environment that is sufficiently different from its intended use.

- VV&A analysis of environmental simulation
- VV&A analysis of environmental simulation different from intended use
- Argent, Robert (2005). A Case Study of Environmental Modeling and Simulation Using Transplantable Components. *Environmental Modeling & Software*, 20(12), 1514-1523 Retrieved November 1, 2007 from [http://www.sciencedirect.com/science?\\_ob=ArticleURL&\\_udi=B6VHC-4GSBFSH-2&...](http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6VHC-4GSBFSH-2&...)
- Foundations for Verification and Validation of the Natural Environment in a Simulation. 2004. Retrieved October 23, 2007 from [wa.dmsi.mil/SpecialTopics/Environment/environment.hrm](http://wa.dmsi.mil/SpecialTopics/Environment/environment.hrm)

*Competency Level: Mastery*

- xxi) Hour 21: Given a case study, analyze if the environmental factors are modeled in sufficient detail to support program milestone decision requirements.

- sufficiency of detail in environmental factors
- program milestones
- decision requirements
- Stevens, Clark D., Brett Butler Charles Campbell, Jon Watkins, Eric Root, Henry Marshall, Teresita Sotomayor. A Common Runtime Format for Virtual and Constructive Simulations. Retrieved October 23, 2007 from [file:///C:/Documents and Settings/mtgillis/Desktop/htmlSNE\\_SRTM\\_Precision\\_Data.html](file:///C:/Documents and Settings/mtgillis/Desktop/htmlSNE_SRTM_Precision_Data.html).
- Stevens, Clark D., Dale D., Miller, Steve Prager, Charles Campbell, Jon Watkins, Eric Root, James Oneal. Data Modeling Implications for a Data Driven Environmental Software Sub-System. Retrieved October 23, 2007 from [file:///C:/Documents and Settings/mtgillis/Desktop/htmlSNE\\_SRTM\\_Precision\\_Data.html](file:///C:/Documents and Settings/mtgillis/Desktop/htmlSNE_SRTM_Precision_Data.html)
- Best Practices – Modeling and Simulation Verification, Validation and Accreditation (VV&A) Guidebook. Retrieved October 23, 2007 from [http://www.drdc.gc.ca/seco/documents/VVA\\_Guidebookk\\_DND\\_SECO\\_May\\_\\_2003\\_e.html](http://www.drdc.gc.ca/seco/documents/VVA_Guidebookk_DND_SECO_May__2003_e.html).

*Competency Level: Mastery*

- xxii) Hour 22: Given a case study, analyze if the environmental factors are modeled in sufficient detail to support program milestone decision requirements.
- sufficiency of detail in environmental factors
  - program milestones
  - decision requirements
  - Stevens, Clark D., Brett Butler, Charles Campbell, Jon Watkins, Eric Root, Henry Marshall, Teresita Sotomayor. A Common Runtime Format for Virtual and Constructive Simulations. Retrieved October 23, 2007 from [file:///C:/Documents and Settings/ntgillis/Desktop/htmlSNE\\_SRTM\\_Precision\\_Data.html](file:///C:/Documents and Settings/ntgillis/Desktop/htmlSNE_SRTM_Precision_Data.html).
  - Stevens, Clark D., Dale D., Miller, Steve Prager, Charles Campbell, Jon Watkins, Eric Root, James Oneal. Data Modeling Implications for a Data Driven Environmental Software Sub-System. Retrieved October 23, 2007 from [file:///C:/Documents and Settings/mtgillis/Desktop/htmlSNE\\_SRTM\\_Precision\\_Data.html](file:///C:/Documents and Settings/mtgillis/Desktop/htmlSNE_SRTM_Precision_Data.html).
  - Best Practices – Modeling and Simulation Verification, Validation and Accreditation (VV&A) Guidebook. Retrieved October 23, 2007 from [http://www.drdc.gc.ca/seco/documents/VVA\\_Guidebookk\\_DND\\_SECO\\_May\\_\\_2003\\_e.html](http://www.drdc.gc.ca/seco/documents/VVA_Guidebookk_DND_SECO_May__2003_e.html).

*Competency Level: Mastery*

- xxiii) Hour 23: Given a case study, analyze if the environmental factors are modeled in sufficient detail to support program milestone decision requirements.
- sufficiency of detail in environmental factors
  - program milestones
  - decision requirements
  - Stevens, Clark D., Brett Butler, Charles Campbell, Jon Watkins, Eric Root, Henry Marshall, Teresita Sotomayor. A Common Runtime Format for Virtual and Constructive Simulations. Retrieved October 23, 2007 from [file:///C:/Documents and Settings/ntgillis/Desktop/htmlSNE\\_SRTM\\_Precision\\_Data.html](file:///C:/Documents and Settings/ntgillis/Desktop/htmlSNE_SRTM_Precision_Data.html).
  - Stevens, Clark D., Dale D., Miller, Steve Prager, Charles Campbell, Jon Watkins, Eric Root, James Oneal. Data Modeling Implications for a Data Driven Environmental Software Sub-System. Retrieved October 23, 2007 from [file:///C:/Documents and Settings/mtgillis/Desktop/htmlSNE\\_SRTM\\_Precision\\_Data.html](file:///C:/Documents and Settings/mtgillis/Desktop/htmlSNE_SRTM_Precision_Data.html).

[Settings\mtgillis\Desktop\htmlSNE\\_SRTM\\_Precision\\_Data.html](file:///C:/Documents and Settings/mtgillis/Desktop/htmlSNE_SRTM_Precision_Data.html)

- Best Practices – Modeling and Simulation Verification, Validation and Accreditation (VV&A) Guidebook. Retrieved October 23, 2007 from [http://www.drdc.gc.ca/seco/documents/VVA\\_Guidebookk\\_DND\\_SECO\\_May\\_\\_2003\\_e.html](http://www.drdc.gc.ca/seco/documents/VVA_Guidebookk_DND_SECO_May__2003_e.html).

*Competency Level: Mastery*

- xxiv) Hour 24: Given a case study, analyze if the environmental factors are modeled in sufficient detail to support T&E requirements.
- sufficiency of detail in environmental factors
  - T&E requirements
  - Best Practices – Modeling and Simulation Verification, Validation and Accreditation (VV&A) Guidebook. Retrieved October 23, 2007 from [http://www.drdc.gc.ca/seco/documents/VVA\\_Guidebookk\\_DND\\_SECO\\_May\\_\\_2003\\_e.html](http://www.drdc.gc.ca/seco/documents/VVA_Guidebookk_DND_SECO_May__2003_e.html).
  - Richbourg, Robert, Institute for Defense Analysis. Digital Elevation Model Resolution and Simulated Natural Environment Terrain Representation Fidelity. Retrieved November 1, 2007 from [www.sisostds.org/index.php?tg=articles&idx+More&article=45&article203-24k](http://www.sisostds.org/index.php?tg=articles&idx+More&article=45&article203-24k)
  - Final Precision Data Product Descriptions. Retrieved October 23, 2007 from [file:///C:/Documents and Settings/mtgillis/Desktop/htmlSNE\\_SRTM\\_Precision\\_Data.html](file:///C:/Documents and Settings/mtgillis/Desktop/htmlSNE_SRTM_Precision_Data.html).

*Competency Level: Mastery*

- xxv) Hour 25: Given a case study, analyze if the environmental factors are modeled in sufficient detail to support T&E requirements.
- sufficiency of detail in environmental factors
  - T&E requirements
  - Best Practices – Modeling and Simulation Verification, Validation and Accreditation (VV&A) Guidebook. Retrieved October 23, 2007 from [http://www.drdc.gc.ca/seco/documents/VVA\\_Guidebookk\\_DND\\_SECO\\_May\\_\\_2003\\_e.html](http://www.drdc.gc.ca/seco/documents/VVA_Guidebookk_DND_SECO_May__2003_e.html).
  - Richbourg, Robert, Institute for Defense Analysis. Digital Elevation Model Resolution and Simulated Natural Environment Terrain Representation Fidelity. Retrieved November 1, 2007 from [www.sisostds.org/index.php?tg=articles&idx+More&article=45&article203-24k](http://www.sisostds.org/index.php?tg=articles&idx+More&article=45&article203-24k)

- Final Precision Data Product Descriptions. Retrieved October 23, 2007 from [file:///C:/Documents and Settings/mtgillis/Desktop/htmlSNE\\_SRTM\\_Precision\\_Data.html](file:///C:/Documents%20and%20Settings/mtgillis/Desktop/htmlSNE_SRTM_Precision_Data.html).

*Competency Level: Mastery*

- xxvi) Hour 26: Given a case study, analyze if the environmental factors are modeled in sufficient detail to support T&E requirements.
  - sufficiency of detail in environmental factors
  - T&E requirements
- Best Practices – Modeling and Simulation Verification, Validation and Accreditation (VV&A) Guidebook. Retrieved October 23, 2007 from [http://www.drdc.gc.ca/seco/documents/VVA\\_Guidebook/DND\\_SECO\\_May\\_2003\\_e.html](http://www.drdc.gc.ca/seco/documents/VVA_Guidebook/DND_SECO_May_2003_e.html).
- Richbourg, Robert, Institute for Defense Analysis. Digital Elevation Model Resolution and Simulated Natural Environment Terrain Representation Fidelity. Retrieved November 1, 2007 from [www.sisostds.org/index.php?tg=articles&idx+More&article=45&article203-24k](http://www.sisostds.org/index.php?tg=articles&idx+More&article=45&article203-24k)
- Final Precision Data Product Descriptions. Retrieved October 23, 2007 from [file:///C:/Documents and Settings/mtgillis/Desktop/htmlSNE\\_SRTM\\_Precision\\_Data.html](file:///C:/Documents%20and%20Settings/mtgillis/Desktop/htmlSNE_SRTM_Precision_Data.html).

### **E13) Human Systems Integration**

**Describe the principles of Human Systems Integration. Describe the applications of M&S to support HSI design and analysis.**

- 1) Module name: Human Systems Integration
- 2) Module coordinator/POC: Anthony Genna  
UCSD Extension  
Assistant Director,  
Defense Technology  
agenna@ucsd.edu  
858-603-2170 (cell)
- 3) Module description: Develop appropriate skills related to the fundamentals of Human Systems Integration. Describe the applications of M&S to support HSI design and analysis. The UCSD E-13 module reflects the Human Systems Engineering (HSE) aspect of human factors rather than just the HSI.
- 4) ESRs that the module supports and the corresponding level of mastery: UAH E13
- 5) Prerequisites assumed, and corresponding level of mastery: training and education (i.e., BS/MS degree or DAU/DoD courses, certifications, etc.) meeting requirements of current position and/or rank/grade/rate. DAU/DoD courses equivalent to the content of the text books listed below:
  - a) Evaluation of Human Work, Third Edition. John R. Wilson and Nigel Corlett, Taylor and Francis, CRC press 2005.
  - b) Handbook of Human Systems Integration, Harold R. Booher, Wiley & Sons, 2003

In addition it is recommended that students have academic training or OJT equivalent to the following levels of competency:

- (1) M&S “GA” module: General Awareness in current job position
  - (2) M&S “UN” module: Understanding in current job position
  - (3) M&S “AP” module: Application in current job position
  - (4) M&S “MA” module: Mastery in current job position
- 6) Module maturity: TBD
  - 7) Number of hours estimated to deliver/teach module: 26 hours
    - a) General Awareness 3 hours
    - b) Understanding 5 hours
    - c) Application 8 hours
    - d) Mastery 10 hours

- 8) Proposed Delivery modality:  
 - (face-to-face, VTC, customer's site)

- 9) Proposed references and texts:

Text will be a current, entry-level M&S text to be identified by the instructor at time of delivery. Additional reference material will include current available literature selected by the instructor for practical application in support of the curriculum. Other supporting text/reference material will be student contributions of relevant material from their experience.

- Simulation Based Acquisition: A New Approach, Report of the Military Research Fellows DSMC 1997-1998

#### Human Factors (HSI/HSE) References:

MIL-STD-1472/ IDEA Hyperlink: The IDEA Hypertext Tool for MIL-STD-1472 (HT-1472) evolved from a demonstrated need to quickly locate and extract specific items of information from MIL-STD-1472, entitled "Human Engineering Design Criteria for Military Systems, Equipment and Facilities." The objective of the tool is to assist an analyst in quickly and accurately identifying and accessing required sections or criteria of MIL-STD-1472

MIL-STD-1472F establishes general human engineering criteria for design and development of military systems, equipment and facilities. Its purpose is to present human engineering design criteria, principles and practices to be applied in the design of systems, equipment and facilities so as to: a) achieve required performance by operator, control, and maintenance personnel; b) minimize skill and personnel requirements, and training time; c) achieve required reliability of personnel-equipment combinations; d) foster design standardization within and among systems.

MIL-STD-1474 It is important to distinguish among the three types to choose the proper one for application and use in various situations. This document is based on the provisions of DA PAM 40-501, OPNAVINST 5100.23B, OPNAVINST 5100.19B, and AFOSHSTD 48-19 for noise exposure criteria and MIL-STD-1472 for communications criteria. This standard applies to the acquisition and product improvement of all designed or purchased (non-developmental items) systems, subsystems, equipment, and facilities that emit acoustic noise. This standard is intended to address noise levels emitted during the full range of typical operational conditions.

MIL-HDBK-759 Department of Defense Handbook for Human Engineering Design Guidelines, was being converted to a tri-service handbook including

data removed from MIL-STD-1472D and the Air Force Systems Command (AFSC) Design Handbook (DH) 1-3

MIL-HDBK-759C Department of Defense Handbook for Human Engineering Design Guidelines This handbook provides basic guidelines and data on human engineering design for military systems, equipment, and facilities, and was designed to supplement MIL-STD-1472 (see entry for MIL-STD-1472E). To cue the MIL-STD-1472E user to such supplementary information, this handbook has been formatted to follow the same paragraph numbering, down to the third indenture level, as in MIL-STD-1472E, e.g. paragraph 5.4.5 of both MIL-STD-1472E and MIL-HDBK-759C deal with miniature controls.

MIL-HDBK-1908B This handbook consolidates definitions of terms used in Defense human factors standardization (HFAC) documents by providing common meanings of such terms to ensure that they will be interpreted consistently and in the manner intended, thereby eliminating overlap, duplication, and conflict. As other HFAC documents were revised, they dropped the contents of their "Definitions" sections in favor of this handbook.

- 10) Module learning objectives: Develop appropriate skills related to the fundamentals of Human Systems Integration. Describe the applications of M&S to support HSI/HSE design and analysis.

E13.1	Demonstrate competency applied to both Human System Integration and Human Systems Engineering (HSI/HSE)
E13.2	Demonstrate competency applied to system Ergonomics
E13.3	Demonstrate competency applied to system audio and visual design
E13.4	Demonstrate competency applied to effective system operability.
E13.5	Demonstrate competency applied to the LCC acquisition process.

- 11) Course assessment plan: Team projects/case studies, discussion, written questions

- 12) Topic list by hour of instruction and reference:

The hours of instruction are categorized based on the level of competency required. As a result of this format hour structure starts at a level of general awareness and progresses

through mastery. This will allow the course material to be easily segmented into each one of the 4 levels of competency.

Hours	ESR Syllabus	Ref
1-3	Student will demonstrate basic understanding the HSI/HSE process	Ref [1]
4	Student will demonstrate basic understanding HIS/HSE system design topics	Ref [1]
5	Student will demonstrate basic understanding System Ergonomics	Ref [1]
6	Student will demonstrate basic understanding System audio and visual design	Ref [1]
7	Student will demonstrate basic understanding Effective system operability	Ref [1]
8	Student will demonstrate basic understanding LCC acquisition process	Ref [1]
9-10	Student will demonstrate ability to use M&S application techniques that support Ergonomic system design.	Ref [1]
11-12	Student will demonstrate ability to use M&S application techniques that support audio and visual design	Ref [1]
13-14	Student will demonstrate ability to use M&S application techniques that support the design of system operability capabilities	Ref [1]
15-16	Student will demonstrate ability to use M&S application techniques that support the LCC acquisition process	Ref [1]
17	Student will demonstrate ability to use M&S techniques related to HSI/HSE Ergonomic development based on M&S Case Studies	Ref [1]
18	Student will demonstrate ability to use M&S techniques related to HSI/HSE Ergonomic development and M&S team project recognizing and/or determining M&S solutions for improved ergonomics.	Ref [1]
19	Student will demonstrate ability to use M&S techniques related to HSI/HSE acoustic noise based on M&S Case Studies	Ref [1]
20	Student will demonstrate ability to use M&S techniques related to HSI/HSE acoustic noise and M&S team project recognizing and/or determining M&S solution for improved noise reduction and or the selection of audio alert signals.	Ref [1]
21	Student will demonstrate ability to use M&S techniques related to HSI/HSE operability based on M&S Case Studies	Ref [1]
22	Student will demonstrate ability to use M&S techniques related to HSI/HSE operability and related M&S team project recognizing and/or determining M&S solution for improved operability	Ref [1]
23	Student will demonstrate ability to use HSI/HSE M&S techniques related to LLC based on M&S Case Studies	Ref [1]
24-26	Student will demonstrate ability to use HSI/HSE M&S techniques related to LLC and M&S team project recognizing and/or determining M&S solutions for cost savings and risk mitigation in the acquisition decision process.	Ref [1]

Ref [1] TBD by NPS Partners.



- 
- 1) Module E13-G Human Systems Integration (General Awareness)
  - 2) Coordinators  
 Dr. Jeff Little, UAH CMSA, 256-824-2351, [jl0001@uah.edu](mailto:jl0001@uah.edu)  
 Dr. Mikel Petty, UAH CMSA, 256-824-4368, [pettym@uah.edu](mailto:pettym@uah.edu)
  - 3) Module description This module depicts the training required for program managers, systems engineers, and T&E workforce members to have a general awareness of Human Systems Integration and its role in acquisition.
  - 4) ESRs that the module supports and the corresponding level of mastery  
 E13 General Awareness
  - 5) Prerequisites assumed, and corresponding level of mastery
  - 6) Module maturity
  - 7) Number of hours estimated to deliver/teach module 5 hours
  - 8) Proposed delivery modality face-to-face, on-line
  - 9) Proposed references and texts (topics refer to these by number)  
 [1] (<http://www.nps.edu/or/hsi/>)  
 [2] DODI 5000.2  
 [3] Defense Acquisition Guidebook, Chapter 6  
 [4] Malonet, T.B., Baker, C.C., Kirkpatrick M., Anderson, D.E., Bost J.R., Williams, C.D., Walker S.A., & Hu, T.H.G. (1998) Payoffs and challenges of human systems integration (HSI) modeling and simulations in a virtual environment. *Naval Engineers Journal*, (110, 4), p 21-37
  - 10) Module learning objectives
    - a) E13.1 Define Human Systems Integration (HSI).
    - b) E13.2 Detail HSI requirements outlined in DODI 5000.2.
    - c) E13.3 Describe the role of M&S in meeting HSI requirements.
    - d) E13.4 Describe how the modeling of HSI can improve system performance.
    - e) E13.5 Describe how the modeling of HSI can reduce system life cycle costs.
    - f) E13.6 Describe the potential benefits from HSI M&S on the system user population.
    - g) E13.7 List and describe existing M&S tools that are specifically structured to support HSI M&S.
  - 11) Course assessment plan End of Module Examination

12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)

12. Introduction and Overview (course notes and syllabus)
  - a. What is Human Systems Integration?; E13.1; [1]
  - b. Review the different types of HSI (Human Factors Engineering, System Safety, Health Hazards, Personnel Survivability, Manpower, Personnel, Training, Habitability); E13.1; [3]
13. HSI requirements outlined in DODI 5000.2 and using M&S to meet those requirements; E13.2 E13.3; [2]
14. Use of HSI modeling in system performance and system life cycle costs; E13.4 E13.5; [3]
15. Use of HSI modeling on system user population; E13.6; [4]
16. Overview of existing M&S tools that support HSI M&S (this will need to be a dynamic compilation of existing and emerging industry standard software which supports HSI M&S—for example, *Delmia* is currently popular within the automotive industry and is being considered for use by NASA); E13.7

- 1) Module E13-U Human Systems Integration (Understand)
- 2) Coordinators  
 Dr. Jeff Little, UAH CMSA, 256-824-2351, [jk10001@uah.edu](mailto:jk10001@uah.edu)  
 Dr. Mikel Petty, UAH CMSA, 256-824-4368, [pettym@uah.edu](mailto:pettym@uah.edu)
- 3) Module description This module depicts the training required for program managers, systems engineers, and T&E workforce members to understand Human Systems Integration and its role in acquisition.
- 4) ESRs that the module supports and the corresponding level of mastery  
 E13 Understand
- 5) Prerequisites assumed, and corresponding level of mastery
- 6) Module maturity
- 7) Number of hours estimated to deliver/teach module 6 hours
- 8) Proposed delivery modality face-to-face, on-line
- 9) Proposed references and texts (topics refer to these by number)  
 [1] (<http://www.nps.edu/or/hsi/>)  
 [2] DODI 5000.2  
 [3] Defense Acquisition Guidebook, Chapter 6

[4] Malonet, T.B., Baker, C.C., Kirkpatrick M., Anderson, D.E., Bost J.R., Williams, C.D., Walker S.A., & Hu, T.H.G. (1998) Payoffs and challenges of human systems integration (HSI) modeling and simulations in a virtual environment. *Naval Engineers Journal*, (110, 4), p 21-37

10) Module learning objectives

- a) E13.1 Define Human Systems Integration (HSI).
- b) E13.2 Detail HSI requirements outlined in DODI 5000.2.
- c) E13.3 Describe the role of M&S in meeting HSI requirements.
- d) E13.4 Describe how the modeling of HSI can improve system performance.
- e) E13.5 Describe how the modeling of HSI can reduce system life cycle costs.
- f) E13.6 Describe the potential benefits from HSI M&S on the system user population.
- g) E13.7 List and describe existing M&S tools that are specifically structured to support HSI M&S.

11) Course assessment plan End of Module Examination

12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)

17. Introduction and Overview (course notes and syllabus)

- a. What is Human Systems Integration?; E13.1; [1]
- b. Review the different types of HSI (Human Factors Engineering, System Safety, Health Hazards, Personnel Survivability, Manpower, Personnel, Training, Habitability); E13.1; [3]

18. HSI requirements outlined in DODI 5000.2 and using M&S to meet those requirements; E13.2 E13.3;[2]

19. Use of HSI modeling in system performance; E13.4; [3]

20. Use of HSI modeling in system life cycle costs; E13.5; [3]

21. Use of HSI modeling on system user population; E13.6; [4]

22. Overview of existing M&S tools that support HSI M&S (this will need to be a dynamic compilation of existing and emerging industry standard software which supports HSI M&S—for example, *Delmia* is currently popular within the automotive industry and is being considered for use by NASA); E13.7

1) Module E13-A Human Systems Integration (Application)

2) Coordinators

Dr. Jeff Little, UAH CMSA, 256-824-2351, [jk10001@uah.edu](mailto:jk10001@uah.edu)

Dr. Mikel Petty, UAH CMSA, 256-824-4368, [pettym@uah.edu](mailto:pettym@uah.edu)

3) Module description This module depicts the training required for program managers, systems engineers, and T&E workforce members to apply Human Systems

Integration and its role in acquisition.

- 4) ESRs that the module supports and the corresponding level of mastery  
E13 Application
- 5) Prerequisites assumed, and corresponding level of mastery
- 6) Module maturity
- 7) Number of hours estimated to deliver/teach module 8 hours
- 8) Proposed delivery modality face-to-face, on-line
- 9) Proposed references and texts (topics refer to these by number)
  - [1] (<http://www.nps.edu/or/hsi/>)
  - [2] DODI 5000.2
  - [3] Defense Acquisition Guidebook, Chapter 6
  - [4] Malonet, T.B., Baker, C.C., Kirkpatrick M., Anderson, D.E., Bost J.R., Williams, C.D., Walker S.A., & Hu, T.H.G. (1998) Payoffs and challenges of human systems integration (HSI) modeling and simulations in a virtual environment. *Naval Engineers Journal*, (110, 4), p 21-37.
- 10) Module learning objectives
  - a) E13.1 Define Human Systems Integration (HSI).
  - b) E13.2 Detail HSI requirements outlined in DODI 5000.2.
  - c) E13.3 Describe the role of M&S in meeting HSI requirements.
  - d) E13.4 Describe how the modeling of HSI can improve system performance.
  - e) E13.5 Describe how the modeling of HSI can reduce system life cycle costs.
  - f) E13.6 Describe the potential benefits from HSI M&S on the system user population.
  - g) E13.7 List and describe existing M&S tools that are specifically structured to support HSI M&S.
- 11) Course assessment plan End of Module Examination
- 12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)
  23. Introduction and Overview (course notes and syllabus)
    - a. What is Human Systems Integration?; E13.1; [1]
    - b. Review the different types of HSI (Human Factors Engineering, System Safety, Health Hazards, Personnel Survivability, Manpower, Personnel, Training, Habitability); E13.1; [3]
  24. Hour one continued
  25. HSI requirements outlined in DODI 5000.2 and using M&S to meet those requirements; E13.2 E13.3; [2]

26. Use of HSI modeling in system performance; E13.4; [3]
  27. Use of HSI modeling in system life cycle costs; E13.5; [3]
  28. Use of HSI modeling on system user population; E13.6; [4]
  29. Overview of existing M&S tools that support HSI M&S (this will need to be a dynamic compilation of existing and emerging industry standard software which supports HSI M&S—for example, *Delmia* is currently popular within the automotive industry and is being considered for use by NASA); E13.7
  30. Applications of HSI? (UAV Operations, Command & Control, Sleep and fatigue in military operations, High-speed Vessel (HSV), C4ISR Data Fusion, Littoral Ship Combatant Program); E13.7; [1]
- 

- 1) Module E13-M Human Systems Integration (Mastery)
- 2) Coordinators  
Dr. Jeff Little, UAH CMSA, 256-824-2351, [jk10001@uah.edu](mailto:jk10001@uah.edu)  
Dr. Mikel Petty, UAH CMSA, 256-824-4368, [pettym@uah.edu](mailto:pettym@uah.edu)
- 3) Module description This module depicts the training required for program managers, systems engineers, and T&E workforce members to obtain Mastery level in Human Systems Integration and its role in acquisition.
- 4) ESRs that the module supports and the corresponding level of mastery  
E13 Mastery
- 5) Prerequisites assumed, and corresponding level of mastery
- 6) Module maturity
- 7) Number of hours estimated to deliver/teach module 9 hours
- 8) Proposed delivery modality face-to-face
- 9) Proposed references and texts (topics refer to these by number)  
[1] (<http://www.nps.edu/or/hsi/>)  
[2] DODI 5000.2  
[3] Defense Acquisition Guidebook, Chapter 6  
[4] Malonet, T.B., Baker, C.C., Kirkpatrick M., Anderson, D.E., Bost J.R., Williams, C.D., Walker S.A., & Hu, T.H.G. (1998) Payoffs and challenges of human systems integration (HSI) modeling and simulations in a virtual environment. *Naval Engineers Journal*, (110, 4), p 21-37
- 10) Module learning objectives
  - a) E13.1 Define Human Systems Integration (HSI).
  - b) E13.2 Detail HSI requirements outlined in DODI 5000.2.

- c) E13.3 Describe the role of M&S in meeting HIS requirements.
- d) E13.4 Describe how the modeling of HSI can improve system performance.
- e) E13.5 Describe how the modeling of HSI can reduce system life cycle costs.
- f) E13.6 Describe the potential benefits from HSI M&S on the system user population.
- g) E13.7 List and describe existing M&S tools that are specifically structured to support HSI M&S.

11) Course assessment plan End of module examination

12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)

- 31. Introduction and Overview (course notes and syllabus)
  - a. What is Human Systems Integration?; E13.1; [1]
  - b. Review the different types of HSI (Human Factors Engineering, System Safety, Health Hazards, Personnel Survivability, Manpower, Personnel, Training, Habitability); E13.1; [3]
- 32. Hour One Continued
- 33. HSI requirements outlined in DODI 5000.2 and using M&S to meet those requirements; E13.2 E13.3; [2]
- 34. Use of HSI modeling in system performance; E13.4; [3]
- 35. Use of HSI modeling in system life cycle costs; E13.5; [3]
- 36. Use of HSI modeling on system user population; E 13.6; [4]
- 37. Overview of existing M&S tools that support HSI M&S (this will need to be a dynamic compilation of existing and emerging industry standard software which supports HSI M&S—for example, *Delmia* is currently popular within the automotive industry and is being considered for use by NASA); E13.7
- 38. Applications of HSI? (UAV Operations, Command & Control, Sleep and fatigue in military operations, High-speed Vessel (HSV), C4ISR Data Fusion, Littoral Ship Combatant Program); E13.7; [1]
- 39. Hour Eight Continued

**E14) Aerodynamics**

**Describe the principles of aerodynamics with applications to M&S. Describe the cost, schedule, and iterative development nature of simulation testbeds used for flight software development through formal qualification.**

- 1) Module E14-G Aerodynamics (General Awareness)
- 2) Coordinators  
 Dr. Jeff Little, UAH CMSA, 256-824-2351, [jk10001@uah.edu](mailto:jk10001@uah.edu)  
 Dr. Mikel Petty, UAH CMSA, 256-824-4368, [pettym@uah.edu](mailto:pettym@uah.edu)
- 3) Module description This module depicts the training required for program managers, systems engineers, and T&E workforce members to have a general awareness of the principles of aerodynamics with applications to M&S and their role in acquisition.
- 4) ESRs that the module supports and the corresponding level of mastery  
 E14 General Awareness
- 5) Prerequisites assumed, and corresponding level of mastery No prerequisites.
- 6) Module maturity Fundamental concepts of aerodynamics are taught at all service academies as well as within service postgraduate programs. These fundamentals are a part of the core curricula at the US Air Force Academy. The level of engineering detail in these programs is far more advanced than required for the training detailed here.
- 7) Number of hours estimated to deliver/teach module 4 hours
- 8) Proposed delivery modality A face-to-face delivery would be ideal due to the wide variation of backgrounds likely to face this engineering-based material. But on-line services, both synchronous and asynchronous, would be useful and probably preferred for those with aerospace engineering backgrounds.
- 9) Proposed references and texts (topics refer to these by number)
  - [1] Understanding Flight, by D. Anderson & S. Eberhardt, McGraw-Hill, 2001
  - [2] Introduction to Flight, 5<sup>th</sup> Edition, by J.D. Anderson, McGraw-Hill, 2005
  - [3] Fundamentals of Aerodynamics, 3<sup>rd</sup> Edition, by J.D. Anderson, McGraw-Hill, 2001
  - [4] Aerodynamics for Engineers, 4<sup>th</sup> Edition, by J.J. Bertin & M.L. Smith, Prentice Hall, Inc., 2002
  - [5] Introduction to Aeronautics: a Design Perspective, by S.A. Brandt, R.J. Stiles, J.J. Bertin & R. Whitford, AIAA Education Series, 1997
  - [6] Stability and Control of Aircraft Systems, by Roy Langton, John Wiley & Sons, 2006

## 10) Module learning objectives

- a) E14.1 Describe the use of flight software for the control of aerodynamic surfaces on flight systems.
- b) E14.2 Describe the fundamentals of controls logic and its relationship to aerodynamics.
- c) E14.3 Explain aerodynamic scaling principles and their use in modeling and testing.
- d) E14.4 Explain the fundamentals of computational fluid dynamics (CFD) and the related strengths, limitations and computational requirements in supporting M&S)
- e) E14.5 Describe the iterative development of flight software and the associated role of M&S.
- f) E14.6 Describe the use of aerodynamic M&S in trade studies early in the system development cycle.
- g) E14.7 Describe the use of aerodynamic M&S in system design optimization.
- h) E14.8 Describe the use of aerodynamic M&S to support flight testing.
- i) E14.9 Describe the iterative validation of aerodynamic simulation testbeds from ground and flight tests and the associated use of validated simulations to reduce testing costs and shorten development cycles for flight software formal qualification.

## 11) Course assessment plan Recommend no assessment at this level other than in-class discussion.

## 12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)

- 40. Introduction and Overview (course notes and syllabus) & Forces in Flight; E14.1-E14.4; [1], [2]
- 41. Controls Theory; E14.2; [6]
- 42. Flight Control; E14.1; [2]
- 43. Use of M&S in Flight Control Development; E14.5-E14.9; [4]

## 1) Module E14-UAerodynamics (Understand)

## 2) Coordinators

Dr. Jeff Little, UAH CMSA, 256-824-2351, [jl0001@uah.edu](mailto:jl0001@uah.edu)

Dr. Mikel Petty, UAH CMSA, 256-824-4368, [pettym@uah.edu](mailto:pettym@uah.edu)

## 3) Module description This module depicts the training required for program managers, systems engineers, and T&amp;E workforce members to gain an understanding of the principles of aerodynamics with applications to M&amp;S and their role in acquisition.

## 4) ESRs that the module supports and the corresponding level of mastery



## E14 Understanding

- 5) Prerequisites assumed, and corresponding level of mastery No prerequisites.
- 6) Module maturity Fundamental concepts of aerodynamics are taught at all service academies as well as within service postgraduate programs. These fundamentals are a part of the core curricula at the US Air Force Academy. The level of engineering detail in these programs is far more advanced than required for the training detailed here.
- 7) Number of hours estimated to deliver/teach module 6 hours
- 8) Proposed delivery modality A face-to-face delivery would be ideal due to the wide variation of backgrounds likely to face this engineering-based material. But on-line services, both synchronous and asynchronous, would be useful and probably preferred for those with aerospace engineering backgrounds.
- 9) Proposed references and texts (topics refer to these by number)
  - [1] Understanding Flight, by D. Anderson & S. Eberhardt, McGraw-Hill, 2001
  - [2] Introduction to Flight, 5<sup>th</sup> Edition, by J.D. Anderson, McGraw-Hill, 2005
  - [3] Fundamentals of Aerodynamics, 3<sup>rd</sup> Edition, by J.D. Anderson, McGraw-Hill, 2001
  - [4] Aerodynamics for Engineers, 4<sup>th</sup> Edition, by J.J. Bertin & M.L. Smith, Prentice Hall, Inc., 2002
  - [5] Introduction to Aeronautics: a Design Perspective, by S.A. Brandt, R.J. Stiles, J.J. Bertin & R. Whitford, AIAA Education Series, 1997
  - [6] Stability and Control of Aircraft Systems, by Roy Langton, John Wiley & Sons, 2006
- 10) Module learning objectives
  - a) E14.1 Describe the use of flight software for the control of aerodynamic surfaces on flight systems.
  - b) E14.2 Describe the fundamentals of controls logic and its relationship to aerodynamics.
  - c) E14.3 Explain aerodynamic scaling principles and their use in modeling and testing.
  - d) E14.4 Explain the fundamentals of computational fluid dynamics (CFD) and the related strengths, limitations and computational requirements in supporting M&S)
  - e) E14.5 Describe the iterative development of flight software and the associated role of M&S.
  - f) E14.6 Describe the use of aerodynamic M&S in trade studies early in the system development cycle.
  - g) E14.7 Describe the use of aerodynamic M&S in system design optimization.
  - h) E14.8 Describe the use of aerodynamic M&S to support flight testing.
  - i) E14.9 Describe the iterative validation of aerodynamic simulation testbeds from ground and flight tests and the associated use of validated simulations to reduce

testing costs and shorten development cycles for flight software formal qualification.

11) Course assessment plan In-class problems with immediate solution feedback.

12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)

- 44. Introduction and Overview (course notes and syllabus) & Forces in Flight; E14.1-E14.9; [1] [2]
- 45. Advanced Flight Concepts; E14.3 E14.4; [4]
- 46. Controls Theory; E14.2; [6]
- 47. Flight Control; E14.1; [2]
- 48. Use of M&S in Flight Control Development; E14.5-E14.9; [5] [journal article support]
- 49. Hour Five Continued

1) Module E14-A Aerodynamics (Application)

2) Coordinators

Dr. Jeff Little, UAH CMSA, 256-824-2351, [jk10001@uah.edu](mailto:jk10001@uah.edu)

Dr. Mikel Petty, UAH CMSA, 256-824-4368, [pettym@uah.edu](mailto:pettym@uah.edu)

3) Module description This module depicts the training required for program managers, systems engineers, and T&E workforce members to be able to apply the principles of aerodynamics with applications to M&S and their role in acquisition.

4) ESRs that the module supports and the corresponding level of mastery  
E14 Application

5) Prerequisites assumed, and corresponding level of mastery No prerequisites.

6) Module maturity Fundamental concepts of aerodynamics are taught at all service academies as well as within service postgraduate programs. These fundamentals are a part of the core curricula at the US Air Force Academy. The level of engineering detail in these programs is far more advanced than required for the training detailed here.

7) Number of hours estimated to deliver/teach module 8 hours

8) Proposed delivery modality A face-to-face delivery would be ideal due to the wide variation of backgrounds likely to face this engineering-based material. But on-line services, both synchronous and asynchronous, would be useful and probably preferred for those with aerospace engineering backgrounds.

9) Proposed references and texts (topics refer to these by number)

- [1] Understanding Flight, by D. Anderson & S. Eberhardt, McGraw-Hill, 2001
- [2] Introduction to Flight, 5<sup>th</sup> Edition, by J.D. Anderson, McGraw-Hill, 2005
- [3] Fundamentals of Aerodynamics, 3<sup>rd</sup> Edition, by J.D. Anderson, McGraw-Hill, 2001
- [4] Aerodynamics for Engineers, 4<sup>th</sup> Edition, by J.J. Bertin & M.L. Smith, Prentice Hall, Inc., 2002
- [5] Introduction to Aeronautics: a Design Perspective, by S.A. Brandt, R.J. Stiles, J.J. Bertin & R. Whitford, AIAA Education Series, 1997
- [6] Stability and Control of Aircraft Systems, by Roy Langton, John Wiley & Sons, 2006

10) Module learning objectives

- a) E14.1 Describe the use of flight software for the control of aerodynamic surfaces on flight systems.
- b) E14.2 Describe the fundamentals of controls logic and its relationship to aerodynamics.
- c) E14.3 Explain aerodynamic scaling principles and their use in modeling and testing.
- d) E14.4 Explain the fundamentals of computational fluid dynamics (CFD) and the related strengths, limitations and computational requirements in supporting M&S)
- e) E14.5 Describe the iterative development of flight software and the associated role of M&S.
- f) E14.6 Describe the use of aerodynamic M&S in trade studies early in the system development cycle.
- g) E14.7 Describe the use of aerodynamic M&S in system design optimization.
- h) E14.8 Describe the use of aerodynamic M&S to support flight testing.
- i) E14.9 Describe the iterative validation of aerodynamic simulation testbeds from ground and flight tests and the associated use of validated simulations to reduce testing costs and shorten development cycles for flight software formal qualification.

11) Course assessment plan In-class problems & case study project with group discussion of various results.

12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)

- 50. Introduction and Overview (course notes and syllabus) & Forces in Flight; E14.1-E14.9; [1] [2]
- 51. Advanced Flight Concepts; E14.3 E14.4; [3]
- 52. Controls Theory; E14.2; [6]
- 53. Flight Control; E14.1; [2]
- 54. Use of M&S in Flight Control Development; E14.5-E14.9; [4]
- 55. Hour five continued
- 56. Case Studies; E14.5-E14.9; [5] [DoD acquisition examples]
- 57. Hour seven continued

- 
- 1) Module E14-M Aerodynamics (Mastery)
  - 2) Coordinators  
 Dr. Jeff Little, UAH CMSA, 256-824-2351, [jl0001@uah.edu](mailto:jl0001@uah.edu)  
 Dr. Mikel Petty, UAH CMSA, 256-824-4368, [pettym@uah.edu](mailto:pettym@uah.edu)
  - 3) Module description This module depicts the training required for program managers, systems engineers, and T&E workforce members to be able to master the principles of aerodynamics with applications to M&S and their role in acquisition.
  - 4) ESRs that the module supports and the corresponding level of mastery E14 Mastery
  - 5) Prerequisites assumed, and corresponding level of mastery No prerequisites.
  - 6) Module maturity Fundamental concepts of aerodynamics are taught at all service academies as well as within service postgraduate programs. These fundamentals are a part of the core curricula at the US Air Force Academy. The level of engineering detail in these programs is far more advanced than required for the training detailed here.
  - 7) Number of hours estimated to deliver/teach module 16 hours
  - 8) Proposed Delivery modality A face-to-face delivery would be ideal due to the wide variation of backgrounds likely to face this engineering-based material. But on-line services, both synchronous and asynchronous, would be useful and probably preferred for those with aerospace engineering backgrounds.
  - 9) Proposed references and texts (topics refer to these by number)  
 [1] Understanding Flight, by D. Anderson & S. Eberhardt, McGraw-Hill, 2001  
 [2] Introduction to Flight, 5<sup>th</sup> Edition, by J.D. Anderson, McGraw-Hill, 2005  
 [3] Fundamentals of Aerodynamics, 3<sup>rd</sup> Edition, by J.D. Anderson, McGraw-Hill, 2001  
 [4] Aerodynamics for Engineers, 4<sup>th</sup> Edition, by J.J. Bertin & M.L. Smith, Prentice Hall, Inc., 2002  
 [5] Introduction to Aeronautics: a Design Perspective, by S.A. Brandt, R.J. Stiles, J.J. Bertin & R. Whitford, AIAA Education Series, 1997  
 [6] Stability and Control of Aircraft Systems, by Roy Langton, John Wiley & Sons, 2006
  - 10) Module learning objectives
    - a) E14.1 Describe the use of flight software for the control of aerodynamic surfaces on flight systems.
    - b) E14.2 Describe the fundamentals of controls logic and its relationship to aerodynamics.
    - c) E14.3 Explain aerodynamic scaling principles and their use in modeling and testing.

- d) E14.4 Explain the fundamentals of computational fluid dynamics (CFD) and the related strengths, limitations and computational requirements in supporting M&S)
- e) E14.5 Describe the iterative development of flight software and the associated role of M&S.
- f) E14.6 Describe the use of aerodynamic M&S in trade studies early in the system development cycle.
- g) E14.7 Describe the use of aerodynamic M&S in system design optimization.
- h) E14.8 Describe the use of aerodynamic M&S to support flight testing.
- i) E14.9 Describe the iterative validation of aerodynamic simulation testbeds from ground and flight tests and the associated use of validated simulations to reduce testing costs and shorten development cycles for flight software formal qualification.

11) Course assessment plan Case Study group presentations & discussions.

12) Topic list by hour of instruction For each is given topic description, related sub-ESR, and reference (if any)

- 58. Introduction and Overview (course notes and syllabus) & Forces in Flight; E14.1-E14.9; [1] [2]
- 59. Hour One Continued
- 60. Advanced Flight; E14.3; [4]
- 61. Hour Three Continued
- 62. Supersonic Flight Concepts; E14.1-E14.4; [2]
- 63. Hour Five Continued
- 64. Controls Theory; E14.2; [6]
- 65. Hour Seven Continued
- 66. Flight Control; E14.1; [1] [6]
- 67. Hour Nine Continued
- 68. Use of M&S in Flight Control Development; E14.5-14.9; [4] [current journal article support]
- 69. Hour Eleven Continued
- 70. Case Studies; E14.5-14.9; [5] [DoD acquisition examples]
- 71. Hour Thirteen Continued
- 72. Hour Thirteen Continued
- 73. Hour Thirteen Continued

## 2.4 Course Syllabi

The course syllabi are presented here in two sections. We present the syllabi for the first 12 courses that have initially been selected for development during the next project spiral in Section 2.4.1. These courses are listed in Figure 2.4.1.

<p>M&amp;S in the Acquisition Life Cycle, Parts One and Two</p> <p>Modeling and Simulation Strategy and Support Plans</p> <p>M&amp;S Requirements and Evaluating M&amp;S Proposals</p> <p>Contracting for M&amp;S</p> <p>Best Practices in M&amp;S</p> <p>M&amp;S in Decision Risk Analysis and Risk Mitigation</p> <p>M&amp;S Environments</p> <p>M&amp;S Data Strategies</p> <p>M&amp;S for Test and Evaluation, Introduction and Advanced</p> <p>Introduction to Engineering M&amp;S Applications</p>
--

Figure 2.4.1 Courses for Development

Based on stakeholder feedback to the initial list of courses, we determined that it was necessary to develop the materials for a certificate based on the engineering ESRs. These course syllabi are currently in development so they are not provided here, but a brief description of the courses follows:

- 1) Introduction to Physics Based Modeling & Simulation - Overview of transforming a physical problem into M&S domain
- 2) Basic Engineering Concepts in M&S I - Fundamentals of M&S in Engineering Structural Systems (Materials, Fluids, Dynamics, Controls, Mechanics)
- 3) Basic Engineering Concepts in M&S II - Overview of Computers, Weapons Platforms and Electrical Systems (Military Systems, Electrical Systems, Computers, C4ISR)
- 4) Applications of Engineering M&S in Land/Sea/Air/Space Systems - Draw upon Case Studies already developed, supplement with additional content specific to focus areas. Demonstrate relationships between engineering M&S and acquisition lifecycle—Design—Production—Testing—Operation/Maintenance—Disposal

Section 2.4.2 provides the complete set of proposed course syllabi. These syllabi are organized by the academic partner that submitted the input. They are available for future development, or as a starting point for development of related course materials if desired.

## 2.4.1 Courses for Development

### Course One

**M&S in the Acquisition Life Cycle, Parts One and Two** – These two courses will be modeled after the Course 1A and Course 1B Syllabi created and submitted by George Mason University to cover A1, A2, P1, P2, and P9. These courses will each be offered as full academic courses and as three day short courses.

- 1) Course Name: M&S in the Acquisition Process, Part 1
- 2) Course coordinator / point of contact and contact information  
Jim Campbell, GMU, [jcampbell@alionscience.com](mailto:jcampbell@alionscience.com), 703-933-3356
- 3) Course description: At the completion of this course, students will be able to describe the Pre-Acquisition M&S activities, and the M&S used in the initial phases of the Acquisition Life Cycle, using the progression of different modeling and simulation applications in use in each phase as a benchmark. They will be able to identify a particular tool and apply it appropriately to the correct point in the lifecycle and relate specific tools to the decision points that separate the acquisition phases. This course is presented at the application level. For courses at the understanding or general awareness level, time can be reduced and practical application periods deleted.
- 4) Modules incorporated into Course This course incorporates ESRs A1, A2, P1, and P9.
- 5) ESRs that the course supports This course incorporates ESRs A1 (Describe the types, role and value of formal Modeling and Simulations, and their various characterizations for application to systems management, particularly with regard to design, testing, training, production, cost estimation, manning, and logistical simulations.); A2 (Understand the critical decisions in the acquisition lifecycle and how/what M&S is used to inform those decisions in order to reduce the time resources and risk associated with the acquisition process.); P1 (Describe the role of modeling and simulation prior to the concept decision to identify and quantify capability gaps and to estimate how well new program concepts might address those gaps.); and P9 (Know models and simulations used in a given phase of the acquisition process, their inputs and outputs, and their capabilities and limitations.).
- 6) Prerequisites: ACQ 101, ACQ 201, Essentials of Modeling and Simulation (MSCO on line orientation: <http://ems.dmsomil/>)
- 7) Course maturity: Some of the course material is presently taught in a different format in the GMU CPE course and in the MSIAC MSSOC.
- 8) Number of contact hours and pace contemplated 24 hours, 1 three-day session
- 9) Proposed Delivery face-to-face, or VTC; resident, or customer's site

## 10) Proposed references and texts:

## a) Acquisition M&amp;S Course Bibliography:

- i) Committee on Modeling and Simulation for Defense Transformation, National Research Council. Defense Modeling, Simulation, and Analysis: Meeting the Challenge. Washington, D.C.: The National Academies Press, 2006.
- ii) Committee on Modeling and Simulation Enhancements for 21<sup>st</sup> Century Manufacturing and Defense Acquisition, National Research Council. Modeling and Simulation in Manufacturing and Defense Acquisition: Pathways to Success. Washington, D.C.: The National Academies Press, 2002.
- iii) Computer Science and Telecommunications Board. Modeling and Simulation: Linking Entertainment and Defense. Washington, D.C.: The National Academies Press, 1997.
- iv) Johnson, Michael V.R., McKeon, Mark F., and Szanto, Terrence R. Simulation Based Acquisition: A New Approach. Fort Belvoir, VA: Defense Systems Management College Press, 1998.
- v) Sabbagh, Karl. Twenty-First-Century Jet: The Making and Marketing of the Boeing 777. New York: Scribner. 1996.
- vi) Schrage, Michael. Serious Play: How the World's Best Companies Simulate to Innovate. Boston: Harvard Business School Press. 2000.

## b) Publications and Regulations

- i) DoD Directive 5000.1, Defense Acquisition System, 12 May 2003
- ii) DoD Instruction 5000.2, Operation of the Defense Acquisition System, 12 May 2003
- iii) DoD Directive 5000.59, DoD Modeling and Simulation (M&S) Management, 8 August 2007
- iv) DoD Instruction 5000.61, DoD Modeling and Simulation (M&S) Verification, Validation, and Accreditation (VV&A), 13 May 2003
- v) Defense Acquisition Guidebook, Version 1.0, 17 October 2004

## c) Joint Chiefs



- i) CJCSI 3170.01F, Joint Capabilities Integration and Development System, 1 May 2007
- ii) CJCSM 3170.01C, Operation of the Joint Capabilities Integration and Development system, 1 May 2007
- d) Services
  - i) AR 70-1, Army Acquisition Policy, 31 December 2003
  - ii) AR 5-11, Management of Army Models & Simulations, 1 February 2005
  - iii) DA PAM 5-11, Verification, Validation and Accreditation of Army Models and Simulations, 30 September 1999
  - iv) DA PAM 5-12, Simulation Support Planning and Plans, 2 March 2005
  - v) DA Pam 70-3, Army Acquisition Procedures, 15 July 1999
  - vi) SECNAVINST 5000.2C, [Operation of the Defense Acquisition System], 19 November 2004
  - vii) SECNAVINST 5200.38A, Department Of The Navy Modeling And Simulation Program, 28 February 2002
  - viii) OPNAVINST 5200.34, Navy Modeling and Simulation (M&S) Management, 28 May 2002
  - ix) DON M&S VV&A Implementation Handbook, Volume I VV&A Framework, 30 March 2004
  - x) AFRPD 63-1 Capabilities-Based Acquisition System, 10 July 2003
  - xi) AFI 63-101, Operations Of Capabilities Based Acquisition System, 29 July 2005
  - xii) AFRPD 16-10 Modeling And Simulation (M&S) Management, 30 January 1995
  - xiii) AFI 16-1002, Modeling and Simulation (M&S) Support to Acquisition, 1 June 2000
  - xiv) Department of Defense Acquisition Modeling and Simulation Master Plan, 17 April, 2006

## 11) Course learning objectives:

- a) A1.1: List the three types of models
- b) A1.2: Describe the purpose and characteristics of each type of model
- c) A1.3: List the three types of simulations
- d) A1.4: Describe the purpose and characteristics of each type of simulation
- e) A1.5: Describe how M&S is used in systems design
- f) A1.9: Describe how M&S is used in systems cost estimation
- g) A1.10: Describe how M&S is used in systems manpower integration
- h) A2.1: Identify the six critical decisions in the acquisition lifecycle.
- i) A2.2: Describe primary and secondary types of M&S functions that support each critical decision.
- j) A2.3: Identify the intended use of each type of M&S supporting the six critical decisions.
- k) A2.4: Identify representative examples of each type of M&S supporting the six critical decisions.
- l) P1.1: Describe the JCIDS process prior to the Concept Decision.
- m) P1.2: Identify the three types of Functional Analyses.
- n) P1.3: Describe how M&S is used in each level of Functional Analysis.
- o) P1.4: Identify the components of DOTMLPF.
- p) P1.5: Describe how M&S is used for DOTMLPF determinations.
- q) P9.1: Identify the five phases of the acquisition life cycle.
- r) P9.2: Identify the principal M&S applications used in each of the five phases of the acquisition life cycle.
- s) P9.3: Describe representative examples of M&S used for each type of application in each phase of the acquisition life cycle.
- t) P9.4: List the inputs, outputs, capabilities and limitations of each example M&S.

## 12) Course assessment plan: Examination, quiz, and practical exercise.

## 13) Topic list by hour of instruction and reference. For example:

- i) Hour one: Overview And Orientation (course notes and syllabus) A1.1- A1.4
- ii) Hour two: Overview And Orientation (course notes and syllabus) A1.1- A1.4  
A2.1- P9.1
- iii) Hour three: M&S in support of the Concept Decision (course notes and syllabus) A2.2-4
- iv) Hour four: Functional Analyses I (course notes and syllabus) P1.1-3
- v) Hour five: Functional Analyses II (course notes and syllabus) P1.1-3
- vi) Hour six: DOTMLPF considerations (course notes and syllabus) P1.4, P1.5
- vii) Hour seven: Practical application (course notes and syllabus) P1 all
- viii) Hour eight: Quiz and review
- ix) Hour nine: M&S in Concept Refinement (course notes and syllabus) P9.2-4
- x) Hour ten: M&S in support of the Milestone A Decision (course notes and syllabus) A2.2-4

- xi) Hour eleven: M&S in system cost estimation and MANPRINT (course notes and syllabus) A1.9-10
- xii) Hour twelve: Practical application Concept Refinement Phase(course notes and syllabus)
- xiii) Hour thirteen: Practical application Concept Refinement Phase(course notes and syllabus)
- xiv) Hour fourteen: M&S in Technology Development (course notes and syllabus) P9.2-4
- xv) Hour fifteen: M&S in support of the Milestone B Decision (course notes and syllabus) A2.2-4
- xvi) Hour sixteen: M&S in system design (course notes and syllabus) A1.5
- xvii) Hour seventeen: Practical application Technology Development (course notes and syllabus)
- xviii) Hour eighteen: Practical application Technology Development (course notes and syllabus)
- xix) Hour nineteen: M&S in System Development (course notes and syllabus) P9.2-4
- xx) Hour twenty: M&S in System Development (course notes and syllabus) P9.2-4
- xxi) Hour twenty-one: M&S in support of the Milestone B Decision (course notes and syllabus) A2.2-4
- xxii) Hour twenty-two: M&S in system training acquisition (course notes and syllabus) A1.7
- xxiii) Hour twenty-three: Practical application (course notes and syllabus)
- xxiv) Hour twenty-four: Examination and summary (course notes and syllabus) A1, A2,P1, and P9

## **Course Two**

- 1) Course Name M&S in the Acquisition Process, Part 2
- 2) Course coordinator / point of contact and contact information  
Jim Campbell, GMU, [jcampbell@alionscience.com](mailto:jcampbell@alionscience.com), 703-933-3356
- 3) Course description: At the completion of this course, students will be able to describe the M&S used in the final phases of the Acquisition Life Cycle, using the progression of different modeling and simulation applications in use in each phase as a benchmark. They will be able to identify a particular tool and apply it appropriately to the correct point in the lifecycle and relate specific tools to the decision points that separate the acquisition phases. They will be able to identify sustainment and training support M&S for a representative system. This course is presented at the application level. For courses at the understanding or general awareness level, time can be reduced and practical application periods deleted.
- 4) Modules incorporated into Course: This course incorporates ESRs A1, A2, P2, and P9.
- 5) ESRs that the course supports This course incorporates ESRs A1 (Describe the types, role and value of formal Modeling and Simulations, and their various characterizations for application to systems management, particularly with regard to design, testing, training, production, cost estimation, manning, and logistical simulations.); A2 (Understand the critical decisions in the acquisition lifecycle and how/what M&S is used to inform those decisions in order to reduce the time resources and risk associated with the acquisition process.); P2 (Assess the costs, benefits, and risks of using physical testing, modeling and simulation, and historical data to provide information for acquisition decisions.); and P9 (Know models and simulations used in a given phase of the acquisition process, their inputs and outputs, and their capabilities and limitations.).
- 6) Prerequisites: ACQ 101, ACQ 201, Course 1A (incorporating ESRs A1, A2, P1, and P9).
- 7) Course maturity: Some of the course material is presently taught in a different format in the GMU CPE course and in the MSIAC MSSOC.
- 8) Number of contact hours and pace contemplated 24 hours, 1 three-day session
- 9) Proposed Delivery face-to-face, or VTC; resident, or customer's site
- 10) Proposed references and texts:
  - e) Acquisition M&S Course Bibliography:

- i) Committee on Modeling and Simulation for Defense Transformation, National Research Council. Defense Modeling, Simulation, and Analysis: Meeting the Challenge. Washington, D.C.: The National Academies Press, 2006.
- ii) Committee on Modeling and Simulation Enhancements for 21<sup>st</sup> Century Manufacturing and Defense Acquisition, National Research Council. Modeling and Simulation in Manufacturing and Defense Acquisition: Pathways to Success. Washington, D.C.: The National Academies Press, 2002.
- iii) Computer Science and Telecommunications Board. Modeling and Simulation: Linking Entertainment and Defense. Washington, D.C.: The National Academies Press, 1997.
- iv) Johnson, Michael V.R., McKeon, Mark F., and Szanto, Terrence R. Simulation Based Acquisition: A New Approach. Fort Belvoir, VA: Defense Systems Management College Press, 1998.
- v) Sabbagh, Karl. Twenty-First-Century Jet: The Making and Marketing of the Boeing 777. New York: Scribner. 1996.
- vi) Schrage, Michael. Serious Play: How the World's Best Companies Simulate to Innovate. Boston: Harvard Business School Press. 2000.
- f) Publications and Regulations
  - i) DoD Directive 5000.1, Defense Acquisition System, 12 May 2003
  - ii) DoD Instruction 5000.2, Operation of the Defense Acquisition System, 12 May 2003
  - iii) DoD Directive 5000.59, DoD Modeling and Simulation (M&S) Management, 8 August 2007
  - iv) DoD Instruction 5000.61, DoD Modeling and Simulation (M&S) Verification, Validation, and Accreditation (VV&A), 13 May 2003
  - v) Defense Acquisition Guidebook, Version 1.0, 17 October 2004
- g) Joint Chiefs
  - i) CJCSI 3170.01F, Joint Capabilities Integration and Development System, 1 May 2007

- ii) CJCSM 3170.01C, Operation of the Joint Capabilities Integration and Development system, 1 May 2007
- h) Services
  - i) AR 70-1, Army Acquisition Policy, 31 December 2003
  - ii) AR 5-11, Management of Army Models & Simulations, 1 February 2005
  - iii) DA PAM 5-11, Verification, Validation and Accreditation of Army Models and Simulations, 30 September 1999
  - iv) DA PAM 5-12, Simulation Support Planning and Plans, 2 March 2005
  - v) DA Pam 70-3, Army Acquisition Procedures, 15 July 1999
  - vi) SECNAVINST 5000.2C, [Operation of the Defense Acquisition System], 19 November 2004
  - vii) SECNAVINST 5200.38A, Department Of The Navy Modeling And Simulation Program, 28 February 2002
  - viii) OPNAVINST 5200.34, Navy Modeling and Simulation (M&S) Management, 28 May 2002
  - ix) DON M&S VV&A Implementation Handbook, Volume I VV&A Framework, 30 March 2004
  - x) AFPD 63-1 Capabilities-Based Acquisition System, 10 July 2003
  - xi) AFI 63-101, Operations Of Capabilities Based Acquisition System, 29 July 2005
  - xii) AFPD 16-10 Modeling And Simulation (M&S) Management, 30 January 1995
  - xiii) AFI 16-1002, Modeling and Simulation (M&S) Support to Acquisition, 1 June 2000
  - xiv) Department of Defense Acquisition Modeling and Simulation Master Plan, 17 April, 2006
- 11) Course learning objectives:
  - u) A1.1: List the three types of models
  - v) A1.2: Describe the purpose and characteristics of each type of model
  - w) A1.3: List the three types of simulations

- x) A1.4: Describe the purpose and characteristics of each type of simulation
- y) A1.5: Describe how M&S is used in systems design
- z) A1.9: Describe how M&S is used in systems cost estimation
- aa) A1.10: Describe how M&S is used in systems manpower integration
- bb) A2.1: Identify the six critical decisions in the acquisition lifecycle.
- cc) A2.2: Describe primary and secondary types of M&S functions that support each critical decision.
- dd) A2.3: Identify the intended use of each type of M&S supporting the six critical decisions.
- ee) A2.4: Identify representative examples of each type of M&S supporting the six critical decisions.
- ff) P2.1: Describe the cost of physical testing vis a vis modeling and simulation, and historical data analysis
- gg) P2.2: Describe the benefits of physical testing vis a vis modeling and simulation, and historical data analysis
- hh) P2.3: Describe the risks of physical testing vis a vis modeling and simulation, and historical data analysis
- ii) P2.4: Describe how physical test, M&S and historical data can be combined to provide effective decision support
- jj) P9.1: Identify the five phases of the acquisition life cycle.
- kk) P9.2: Identify the principal M&S applications used in each of the five phases of the acquisition life cycle.
- ll) P9.3: Describe representative examples of M&S used for each type of application in each phase of the acquisition life cycle.
- mm) P9.4: List the inputs, outputs, capabilities and limitations of each example M&S.

12) Course assessment plan: Examination, quiz, and practical exercise.

13) Topic list by hour of instruction and reference. For example:

- i) Hour one: M&S in System Development and Demonstration (course notes and syllabus) P9.2-4
- ii) Hour two: M&S in support of the Milestone C Decision (course notes and syllabus) A2.2-4
- iii) Hour three: : Practical application (course notes and syllabus) P9, A2
- iv) Hour four: Cost considerations for test vs M&S (course notes and syllabus) P2.1
- v) Hour five: : Benefits for test vs M&S (course notes and syllabus) P2.2
- vi) Hour six: Risk considerations for test vs M&S (course notes and syllabus) P2.3
- vii) Hour seven: Efficient Continuum of test and M&S (course notes and syllabus) P2.4,
- viii) Hour eight: Practical application (course notes and syllabus) P2 all
- ix) Hour nine: : Practical application (course notes and syllabus) P2 all
- x) Hour ten: Quiz and review

- xi) Hour eleven: M&S in Production and Deployment (course notes and syllabus) P9.2-4
- xii) Hour twelve: M&S in support of the Full Rate Production Decision (course notes and syllabus) A2.2-4
- xiii) Hour thirteen: M&S in system testing (course notes and syllabus) A1.6
- xiv) Hour fourteen: M&S in system testing (course notes and syllabus) A1.6
- xv) Hour fifteen: M&S in system production (course notes and syllabus) A1.8
- xvi) Hour sixteen: Practical application Production and Deployment (course notes and syllabus)
- xvii) Hour seventeen: Practical application Production and Deployment (course notes and syllabus)
- xviii) Hour eighteen M&S in System Sustainment (course notes and syllabus) P9.2-4
- xix) Hour nineteen: M&S in system training (course notes and syllabus) A1.7
- xx) Hour twenty: M&S in system support (course notes and syllabus)  
A1.11M&S in System Development (course notes and syllabus) P9.2-4
- xxi) Hour twenty-one: Practical application (course notes and syllabus) notes and syllabus) A2.2-4
- xxii) Hour twenty-two: : Practical application (course notes and syllabus)
- xxiii) Hour twenty-three: Examination and summary (course notes and syllabus) A1, A2,P2, and P9
- xxiv) Hour twenty-four: Examination and summary (course notes and syllabus) A1, A2,P2, and P9



### **Course Three**

**Modeling and Simulation Strategy and Support Plans** – This course will be modeled after the Modeling and Simulation Strategy and Support Plans course syllabi developed to satisfy ESRs P6 and P7 by University of California, San Diego. This course will be offered both as a full academic course and as a 3-6 hour web-based course for General Awareness.

- 1) Course Name: Modeling and Simulation Strategy and Support Plans
- 2) Course coordinator/POC: Anthony Genna  
UCSD Extension  
Assistant Director,  
Defense Technology  
agenna@ucsd.edu  
858-603-2170 (cell)
- 3) Course description: This course is designed to educate and introduce acquisition workforce professionals to modeling and simulation (M&S) and its application to M&S planning and the generation of support plan documents. The general focus of this course is to define and identify the benefits of M&S and its application to the understanding, use and evaluation of M&S planning. The general focus of this course includes: development of an integrated Simulation Support Plan (SSP), System Engineering Plan (SEP), and Test and Evaluation Master Plan (TEMP). Specific focus areas include: the M&S planning process and its relationship to life cycle phases of development and acquisition milestone decisions; program cost, schedule and performance considerations; trade-off decisions; and effectiveness assessment.
- 4) Modules incorporated into the course: P6 (partial); P7 (partial).
- 5) ESR's that the course supports and the corresponding level of achievement:
  - P6.1 (G, U, A, M)
  - P6.2 (G, U, A, M)
  - P6.3 (G, U, A, M)
  - P6.4 (G, U, A, M)
  - P6.5 (G, U, A, M)
  - P7.1 (G, U, A, M)
  - P7.2 (G, U, A, M)
  - P7.3 (G, U, A, M)
  - P7.7 (G, U, A, M)
  - P7.8 (G, U, A, M)
  - P7.9 (U, A, M)
- 6) Prerequisites: This course is designed for DoD military and civilian professionals who are determined to be proficient to the apprentice, journeyman or expert level (as

applicable) in their current job positions in the areas of program management, systems engineering and/or test and evaluation.

- 7) Course maturity: This is a new course. The M&S University of the MSAIC offers several courses with similar basic content to this one. In particular, the M&S Staff Officers Course and Simulation Support Plan Tutorial are complimentary.
- 8) Number of contact hours and pace contemplated: This 36 hour course will provide 4 CEU's. The class will meet 3 hours per week for 12 weeks. The hour breakdown for each level of competency is provided below:
  - a) General Awareness 3 hours
  - b) Understanding 6 hours
  - c) Application 12 hours (9 hr instruction; 2 hr project, 1 hr exam)
  - d) Mastery 15 hours (9 hr instruction; 5 hr project, 1 hr exam)
- 9) Proposed delivery modality: face-to-face.
- 10) Proposed references and texts:

[1] Acquisition M&S Master Plan, 17Apr06  
[http://www.acq.osd.mil/sse/as/docs/AMSMP\\_041706\\_FINAL2.pdf](http://www.acq.osd.mil/sse/as/docs/AMSMP_041706_FINAL2.pdf)  
 [2], [3], [4] Decision Support Guidebook  
<https://akss.dau.mil/dag/GuideBook/PDFs/GBNov2006.pdf>  
 [3] Defense Acquisition Guidebook  
<https://akss.dau.mil/dag/> or  
<https://akss.dau.mil/dag/DoD5000.asp?view=document&doc=2>  
 [4] Systems Engineering Plan Preparation Guide  
[http://www.acq.osd.mil/sse/docs/SEP-Prep-Guide-Ver-2-0\\_18Oct07.pdf](http://www.acq.osd.mil/sse/docs/SEP-Prep-Guide-Ver-2-0_18Oct07.pdf)

Additional useful references:

[5] DA PAM 5-12, Simulation Support Planning and Plans, 2 March 2005  
[http://www.army.mil/usapa/epubs/pdf/p5\\_12.pdf](http://www.army.mil/usapa/epubs/pdf/p5_12.pdf)  
 [6] Australian DoD Life Cycle Simulation Guide  
<http://www.defence.gov.au/capability/adso/docs/Requirements%20Phase%20Guide.pdf>  
 [7] Integrated Master Plan and Schedule  
[http://www.acq.osd.mil/sse/docs/IMP\\_IMS\\_Guide\\_v9.pdf](http://www.acq.osd.mil/sse/docs/IMP_IMS_Guide_v9.pdf)

- 11) Course learning objectives:

P7.1: Define a Simulation Support Plan (SSP) and the relationship to using M&S for acquisition decisions.

P6.1: Relate acquisition cost models to M&S planning.

P6.3: Define cost requirements and justifications as they relate to an M&S plan/SSP.

- P6.4: Develop a schedule for an M&S plan/SSP.
- P6.2: Define measurable performance factors for a given case study.
- P6.5: Assess effectiveness (cost and schedule) of an M&S plan/SSP.
- P7.3: Show how an integrated SSP, SEP and TEMP can be leveraged to reduce risk, cost and schedule issues.
- P7.2: Understand and describe efficient use of M&S planning across life cycle phases of development.
- P7.8: Manage M&S resources and documentation of SSP, SEP and TEMP.
- P7.7: Analyze the rationale for trade-off decisions and selections for SSP, SEP and TEMP strategies.
- P7.9: Create and analyze a case study encompassing SSP, SEP and TEMP concepts.

12) Course assessment plan:

- a) Week 1 through week 12: Weekly quizzes to test competency at corresponding level of instruction.
- b) Week 7: Class project based on case study to demonstrate students' ability to perform at the application level.
- c) Week 7: Mid term exam to test student competency at the application level.
- d) Weeks 11 and 12: Class projects based on case studies to demonstrate students' ability to perform analysis and evaluation at the mastery level.
- e) Week 12: Final exam to test student's ability to perform analysis and evaluation at the mastery level.

13) Topic list by hour of instruction and reference:

The 36 hour course is structured such that each hour is based on its required level of competency. This structure allows the course material to be provided as four separate groupings: General Awareness, Understanding, Application, and Mastery.

General Awareness Skill Level:

- 1-3 Introduction and overview of a Simulation Support Plan (SSP), or M&S plan, and its relationship to using M&S to enable informed acquisition decisions. Introduction and overview of the M&S plan process and documents, such as a System Engineering Plan (SEP) and a Test and Evaluation Master Plan (TEMP). Ref: [1], [2], [3], [4], instructor notes.

Understanding Skill Level:

- 4 Develop steps and objectives of the M&S planning process. Define details of an SSP, and considerations for its incorporation into an SEP and a TEMP. P7.1, to P7.9. Ref: [1], [2], [3], [4], instructor notes.
- 5 Understanding and development of M&S cost models, cost requirements and their justifications. Develop and define the fundamentals of an M&S scheduling and risk mitigation plan. P6.1, P6.3, P6.4. Ref: [1], [2], [3], [4], instructor notes.

- 6 Develop and define performance factors and system design measures that are candidates for simulation. Define the use of an SSP across life cycle phases of development. P6.2, P7.2. Ref: [1], [2], [3], [4], instructor notes.
- 7 Develop an understanding and illustrate how an integrated SSP, SEP and TEMP can be leveraged to reduce risk, cost, and schedule issues. Define the benefits and use of M&S resource management and related documentation. P7.3, P7.8. Ref: [1], [2], [3], [4], instructor notes.
- 8 Develop an understanding of how to perform M&S plan effectiveness assessment. This section includes, but is not limited to: metrics, reuse, integration/interoperability, verification/validation, and uncertainty considerations. P6.5. Ref: [1], [2], [3], [4], instructor notes.
- 9 Understanding of trade-off decisions and their rationale. P7.7. Ref: [1], [2], [3], [4], instructor notes.

*Application Skill Level:*

- 10 Identify and apply a process that supports the development of M&S planning documents and cost considerations. Apply the M&S planning process to acquisition milestones and decisions. P7.1, P6.1. Ref: [1], [2], [3], [4], instructor notes.
- 11-12 Identify and apply a process that supports the development of M&S planning techniques that include cost requirements and their justification in decision-making. Identify and apply a process that supports the development of M&S plan scheduling. P6.3, P6.4. Ref: [1], [2], [3], [4], instructor notes.
- 13 Identify a process that supports the development of measurable, effective M&S assessment plans - documenting and reporting on program milestone goals, progress, performance factors, decisions made, and achievement of objectives. Identify and apply M&S resource management best practices. P6.2, P7.8. Ref: [1], [2], [3], [4], instructor notes.
- 14-15 Identify and apply a process that supports the development of M&S planning techniques related to cost, schedule and program risk reduction, using an integrated SSP, SEP and TEMP. Apply the integrated SSP across life cycle phases of development to support capabilities-based and simulation-based acquisition initiatives, principles and policy. P7.3, P7.2. Ref: [1], [2], [3], [4], instructor notes.
- 16-18 Identify and apply a process that supports the development of M&S plan effectiveness assessment. Define and apply M&S planning processes related to appraisal of trade-off decisions and their rationale. P6.5, P7.7. Ref: [1], [2], [3], [4], instructor notes.
- 19-20 Class team project: Create an M&S plan development case study encompassing an SSP, SEP and TEMP. P7.9. Ref: [1], [2], [3], [4], instructor notes.
- 21 Mid term exam to evaluate student competency at the application level. Ref: [1], [2], [3], [4], [3], instructor notes.

*Mastery Skill Level:*

- 22 Identify and define a process that supports analysis and evaluation of M&S planning documents and cost considerations. Asses the M&S planning process as it relates to acquisition milestones and decisions. P6.1, P7.1. Ref: [1], [2], [3], [4], instructor notes.
- 23-24 Identify and define a process/processes that supports/support analysis and evaluation of M&S planning to determine cost, schedule and performance requirements and assessment metrics. P6.3, P6.4. Ref: [1], [2], [3], [4], instructor notes.
- 25 Identify and define a process that supports analysis and evaluation of M&S planning techniques for determining measurable performance factors for a given set of objectives. Identify and asses M&S planning techniques related to M&S resource management and documentation. P6.2, P7.8. Ref: [1], [2], [3], [4], instructor notes.
- 26-27 Identify and define a process that supports analysis and evaluation of how an integrated SSP can reduce cost, schedule and program risks based on instructor-provided case studies. Apply the integrated SSP across life cycle phases of development to support capabilities-based and simulation-based acquisition initiatives, principles and policy. P7.3, P7.2. Ref: [1], [2], [3], [4], instructor notes.
- 28-29 Identify and define a process that supports analysis and evaluation of trade-off decisions and their rationale in the M&S planning process, based on instructor-provided case studies. P7.7. Ref: [1], [2], [3], [4], instructor notes.
- 30-31 Identify and define a process that supports analysis and evaluation of M&S plan effectiveness (in a class project). P6.5. Ref: [1], [2], [3], [4], instructor notes.
- 32-33 Class team project: Analysis and evaluation (critique) of the M&S plan development case study created during class hours 19-20, encompassing an SSP, SEP and TEMP. P7.9. Ref: [1], [2], [3], [4], instructor notes.
- 34-35 Class project: Evaluate the soundness of the M&S plan details in two instructor-provided case studies. Provide recommended improvements for any weaknesses identified. P7.9. Ref: [1], [2], [3], [4], instructor notes.
- 36 Final exam to evaluate student competency at the mastery level. Ref: [1], [2], [3], [4], instructor notes.

## **Course Four**

**M&S Requirements and Evaluating M&S Proposals** – This course will combine the M&S Requirements and M&S Proposals course syllabi developed to satisfy ESRs P5 and A3 by Old Dominion University. This course will be offered both as a full academic course and as two 3-6 hour web-based courses for General Awareness of each topic.

- 1) Course Name: M&S Requirements
- 2) Course coordinator: Marsha Taliaferro-Gillis, Ph.D.  
6596 Main Street  
Gloucester, VA 23061  
(804)694-3173 (Office)  
(804)824-4663 (Cell)  
mtgillis@werneranderson.com
- 3) Course description: Establish and write valid modeling and simulation requirements using a process that includes modeling and simulation needs analysis, generation of valid modeling and simulation requirements, functional decomposition and conceptual model development, and issuance of “built to” or “buy to” performance specifications. Understand how models and simulations evolve in fidelity, resolution, and scope as the program life cycle progresses.
- 4) Modules incorporated into the Course - P5
- 5) **ESRs that the Course supports and corresponding level of mastery:**
  - a) M&S development and VV&A lifecycle  
*Competency Level: Understanding*
  - b) Domains of M&S requirements  
*Competency Level: Understanding*
  - c) Representational requirements in M&S  
*Competency Level: Understanding*
  - d) Conceptual model development and validation  
*Competency Level: General Awareness*
  - e) Process differences between legacy and new development models  
*Competency Level: Understanding*
  - f) Work products available in M&S development  
*Competency Level: Understanding*
  - g) Changes in M&S fidelity, resolution, and scope across the acquisition lifecycle

*Competency Level: Understanding*

h) Acceptability criteria

*Competency Level: Understanding*

i) Selecting M&S

*Competency Level: Mastery*

j) Developing and Evaluating M&S Requirements

*Competency Level: Mastery*

6) **Prerequisites assumed, and corresponding level of mastery: None**

7) Module maturity: none

8) Number of contact hours and pace contemplated: 3 hours lecture/week for 8 weeks

9) Proposed Delivery modality is face-to-face and/or on-line.

10) Module learning objectives:

P5.1 Describe the M&S development and VV&A lifecycle (for COTS, GOTS and new development M&S)

P5.2 Identify the three domains of M&S requirements (user domain, problem domain, and simulation domain)

P5.3 Describe the types of representational requirements (e.g., entities, actions, tasks, interactions, behaviors) in M&S and standard methods for capturing them (e.g. UML, conceptual model descriptions)

P5.4 Describe how M&S requirements, representational requirements, acceptability criteria, and intended use support conceptual model development and validation

P5.5 Describe the M&S process differences between legacy (no, minor & major modifications) and new development models

P5.6 Describe the work products available in M&S development and their role in VV&A

P5.7 Describe how M&S fidelity, resolution, and scope changes across the acquisition lifecycle (e.g., concept refinement to DT to OTA to OT to training)

P5.8 Describe the role of acceptability criteria in the VV&A process and its relationship to M&S requirements

P5.9 Given a case study, select those requirements which are appropriate for M&S

P5.10 Given a case study and sample acquisition documents (TEMP, CDD, ICD, PSPEC), develop or evaluate requirements for M&S

11) Course learning objectives; Mastery of valid M&S requirements for performance specifications in fidelity, resolution, and scope as program life cycles progress. Mastery demonstrated by a grade of 90% correct on a final course exam.

12) Course assessment plan: Projects and Exams

13) Topic list by hour of instruction and reference.

*Competency Level: Understanding*

i) Hour 1: Introduction and Overview (course notes and syllabus)

*Competency Level: Understanding*

ii) Hour 2: (Sub ESR P5.1). M&S development and VV&A lifecycle for COTS and GOTS. [1] [2] [3]

*Competency Level: Understanding*

iii) Hour 3: (Sub ESR P5.1). M&S development and VV&A lifecycle for new development M&S. [1] [3]

*Competency Level: General Awareness*

iv) Hour 4: (Sub ESR P5.2). The three domains of M&S requirements. [1]

*Competency Level: Understanding*

v) Hour 5: (Sub ESR P5.3). Representational requirements in M&S and standard methods for capturing them. [1]

*Competency Level: Understanding*

vi) Hour 6: (Sub ESR P5.3). Representational requirements in M&S and standard methods for capturing them. [1] [3]

*Competency Level: Understanding*

vii) Hour 7: (Sub ESR P5.4). Conceptual model development and validation

*Competency Level: Understanding*

viii) Hour 8: (Sub ESR P5.4). Conceptual model development and validation. [1] [3]

*Competency Level: General Awareness*

ix) Hour 9: (Sub ESR P5.5). M&S process differences between legacy (no, minor & major modifications) and new development models. [1]

*Competency Level: Understanding*

x) Hour 10: (Sub ESR P5.5). M&S process differences between legacy (no, minor & major modifications) and new development models. [1]

*Competency Level: General Awareness*



- xi) Hour 11: (Sub ESR P5.6). Work products available in M&S development and their role in VV&A. [1] [3] [4]

*Competency Level: Understanding*

- xii) Hour 12: (Sub ESR P5.6). Work products available in M&S development and their role in VV&A. [1] [3] [4]

*Competency Level: Understanding*

- xiii) Hour 13: (Sub ESR P5.7). Changes in M&S fidelity, resolution, and scope across the acquisition lifecycle. [1] [2] [3]

*Competency Level: Understanding*

- xiv) Hour 14: (Sub ESR P5.7). Changes M&S fidelity, resolution, and scope across the acquisition lifecycle. [1] [2] [3]

*Competency Level: Understanding*

- xv) Hour 15: (Sub ESR P5.8). Acceptability criteria in the VV&A process. [1] [3]

*Competency Level: Application*

- xvi) Hour 16: (Sub ESR P5.8). Acceptability criteria in the VV&A process and its relationship to M&S requirements. [1] [3]

*Competency Level: Application*

- xvii) Hour 17: (Sub ESR P5.9). M&S Selection Project. [1] [3]

*Competency Level: Application*

- xviii) Hour 18: (Sub ESR P5.9). M&S Selection Project. [1] [3]

*Competency Level: Mastery*

- xix) Hour 19: (Sub ESR P5.9). M&S Selection Project. [1] [3]

*Competency Level: Application*

- xx) Hour 20: (Sub ESR P5.10). M&S Requirements Development and Evaluation Project [1] [3]

*Competency Level: Application*

- xxi) Hour 21: (Sub ESR P5.10). M&S Requirements Development and Evaluation Project. [1] [3]

*Competency Level: Mastery*

- xxii) Hour 22: (Sub ESR P5.10). M&S Requirements Development and Evaluation Project. [1] [3]

*Competency Level: Mastery*

- xxiii) Hour 23: (Sub ESR P5.10). M&S Requirements Development and Evaluation Project. [1] [3]

*Competency Level: Mastery*

- xxiv) Hour 24: (Sub ESR P5.10). M&S Requirements Development and Evaluation Project. [1] [3]

14) Proposed references and texts:

- [1] Law, A.M., and W.D. Kelton, *Simulation Modeling and Analysis*, Second Edition, McGraw-Hill, Boston, 1991
- [2] DoD. 2004. *Defense Acquisition Guidebook*. <https://akss.dau.mil/dag/>
- [3] DoD. 2006. *VV&A Recommended Practices Guide*. <http://vva.dmsomil/>
- [4] Rubenstein, R. Y., B. Melamel. 1998. *Modern Simulation and Modeling*. John Wiley and Sons, Inc., New York, NY.

### **Course Four Continued**

- 1) Course Name: M&S Proposals
- 2) Course coordinator: Marsha Taliaferro-Gillis, Ph.D.  
6596 Main Street  
Gloucester, VA 23061  
(804)694-3173 (Office)  
(804)824-4663 (Cell)  
mtgillis@werneranderson.com
- 3) Course description: Discernment between M&S proposals, relative to measurable program contributions. Decision making on the appropriate program office level of expenditure on M&S tools throughout the program life cycle. Decisions as to whether custom or off-the-shelf products will be best suited for the program's purpose.
- 4) Modules incorporated into the Course: A3
- 5) **ESRs that the course supports and corresponding level of mastery.**
  - a) The role of M&S throughout the acquisition cycle  
*Competency Level: General Awareness*
  - b) M&S Support Plan.  
*Competency Level: General Awareness*
  - c) Legacy, developmental, GOTS and COTS M&S.  
*Competency Level: General Awareness*
  - d) The V&V process.  
*Competency Level: Understanding*
  - e) M&S reuse.  
*Competency Level: Understanding*
  - f) Application of a sample M&S Support Plan  
*Competency Level: Application*
  - g) Development of an M&S budget.  
*Competency Level: Mastery*
  - h) Analysis and selection from available M&S options.  
*Competency Level: Mastery*

- 6) **Prerequisites assumed, and corresponding level of mastery. General awareness of the government acquisition process.**
- 7) Course maturity: none
- 8) Number of contact hours and pace contemplated: 2.5 hours lecture/week for 8 weeks
- 9) Proposed Delivery modality; face-to-face and/or on-line.
- 10) Module learning objectives:
  - A3.1 Define the role of M&S throughout the acquisition cycle (e.g., Concept Development, DT&E, OT&E, LFT&E, and operations and sustainment)
  - A3.2 Describe the use of an M&S Support Plan throughout the acquisition cycle.
  - A3.3 Define and distinguish between legacy, developmental, GOTS and COTS M&S.
  - A3.4 Understand the V&V process and its impact on M&S usage, acceptability, and cost.
  - A3.5 Understand the benefit and application of M&S reuse across programs and across a single program's lifecycle.
  - A3.6 Apply a sample M&S Support Plan to provide best use of M&S across all stages of the acquisition life-cycle.
  - A3.7 Given a case study and sample M&S Support Plan, develop an M&S budget.
  - A3.8 Given a case study and sample M&S Support Plan, select between available legacy, developmental, GOTS and COTS M&S options.
- 11) Course learning objectives: Mastery of M&S management in the acquisition lifecycle including development and use of an MSSP and evaluation and selection of appropriate and cost effective M&S products. Mastery to be demonstrated by a grade of not less than B+ on final projects and exams.
- 12) Course assessment plan: projects and exams.
- 13) Topic list by hour of instruction and reference:

*Competency Level: General Awareness*

- i) Hour 1: (Sub ESR A3.1). Introduction and Overview (course notes and syllabus). [1]

*Competency Level: General Awareness*

- ii) Hour 2: (Sub ESR A3.1). The Role of M&S in Concept Development and DT&E. [1]

*Competency Level: General Awareness*

- iii) Hour 3: (Sub ESR A3.1). The Role of M&S in OT&E, LFT&E, and Operations and Sustainment. [1]

*Competency Level: General Awareness*

- iv) Hour 4: (Sub ESR A3.2). The Modeling and Simulation Support Plan. [1]  
[2]

*Competency Level: General Awareness*

- v) Hour 5: (Sub ESR A3.2). The MSSP; Requirements Across the Services and Best Practices. [2]

*Competency Level: General Awareness*

- vi) Hour 6: (Sub ESR A3.3). M&S Types and Sources. [3]

*Competency Level: General Awareness*

- vii) Hour 7: (Sub ESR A3.4). Verification and Validation Overview. [4]

*Competency Level: Understanding*

- viii) Hour 8: (Sub ESR A3.4). V&V and M&S application, acceptability and cost. [4]

*Competency Level: Understanding*

- ix) Hour 9: (Sub ESR A3.4). V&V and M&S application, acceptability and cost. [4]

*Competency Level: General Awareness*

- x) Hour 10: (Sub ESR A3.5). M&S Use and Re-use Across Single Program Lifecycle. [1] [5]

*Competency Level: Understanding*

- xi) Hour 11: (Sub ESR A3.5). M&S Use and Re-use Across Multiple Programs. [1] [5]

*Competency Level: General Awareness*

- xii) Hour 12: (Sub ESR A3.6). MSSP Application Project. [1] [5]

*Competency Level: Understanding*

- xiii) Hour 13: (Sub ESR A3.6). MSSP Application Project. [1] [5]

*Competency Level: Application*

- xiv) Hour 14: (Sub ESR A3.6). MSSP Application Project. [1] [5]

*Competency Level: Application*

- xv) Hour 15: (Sub ESR A3.6). MSSP Application Project. [1] [5]

*Competency Level: Mastery*

xvi) Hour 16: (Sub ESR A3.7). MSSP and M&S Budget Project. [1] [5]

*Competency Level: Mastery*

xvii) Hour 17: (Sub ESR A3.7). MSSP and M&S Budget Project. [1] [5]

*Competency Level: Mastery*

xviii) Hour 18: (Sub ESR A3.7). MSSP and M&S Budget Project. [1] [5]

*Competency Level: Mastery*

xix) Hour 19: (Sub ESR A3.8). MSSP and M&S Selection Project. [1] [5]

*Competency Level: Mastery*

xx) Hour 20: (Sub ESR A3.8). MSSP and M&S Selection Project. [1] [5]

#### 14) Proposed references and texts:

[1] DoD. 2004. *Defense Acquisition Guidebook*. <https://akss.dau.mil/dag/>

[2] Department of the Army. 2005. *Simulation Support Planning and Plans*. (DA PAM 5-12) [http://www.army.mil/usapa/epubs/pdf/p5\\_12.pdf](http://www.army.mil/usapa/epubs/pdf/p5_12.pdf)

[3] Rubenstein, R. Y., B. Melamel. 1998. *Modern Simulation and Modeling*. John Wiley and Sons, Inc., New York, NY.

[4] DoD. 2006. *VV&A Recommended Practices Guide*. <http://vva.dmsomil/>

[5] DoD. 1994. *DoD Directive 5000.59 Modeling and Simulation Management*. <https://www.dmsomil/public/library/policy/policy/d500059p.pdf>

## **Course Five**

**Contracting for M&S** - This course will be modeled after the M&S in the Contract Proposal Process course syllabus developed to satisfy ESR A4 by Old Dominion University. This course will be offered both as a full academic course and as a 3-6 hour web-based course for General Awareness.

- 1) Course Name: M&S in the Contract Proposal Process
- 2) Course coordinator: Marsha Taliaferro-Gillis, Ph.D.  
6596 Main Street  
Gloucester, VA 23061  
(804)694-3173 (Office)  
(804)824-4663 (Cell)  
mtgillis@werneranderson.com
- 3) Course description: Recognize contracting issues for M&S products. Include considerations for intellectual property issues, delivery terms, maintenance responsibility, standards for documentation, open architecture, interoperability, reuse and other considerations
- 4) Modules incorporated into the Course - A4
- 5) **ESRs that the course supports and corresponding level of mastery.**
  - a) Intellectual Property Issues in Contracting for M&S products  
*Competency Level: Understanding*
  - b) Terms of Delivery and Contracting for M&S products  
*Competency Level: Understanding*
  - c) Documentation Deliverables  
*Competency Level: Understanding*
  - d) Long-term Maintenance for Contracted M&S products.  
*Competency Level: Understanding*
  - e) Open Architecture  
*Competency Level: Understanding*
  - f) Interoperability  
*Competency Level: Understanding*
  - g) M&S Re-use  
*Competency Level: Understanding*

h) Enforcing M&S Contract Terms  
*Competency Level: Understanding*

i) Drafting M&S contract documents  
*Competency Level: Mastery*

6) **Prerequisites assumed, and corresponding level of mastery:**

7) Course maturity: none

8) Number of contact hours and pace contemplated: 3 hours lecture/week for 6 weeks

9) Proposed Delivery modality: face-to-face and/or on-line.

10) Module learning objectives:

- A4.1 Describe the Intellectual Property issues that arise when contracting for M&S products.
- A4.2 Describe and differentiate between possible Terms of Delivery when contracting for M&S products.
- A4.3 Identify the content, format, and medium the government should require for documentation deliverables.
- A4.4 Understand the long-term maintenance options available to government customers when contracting for M&S products.
- A4.5 Understand issues in using Open Architecture products, including compatibility and continued use of legacy or unsupported systems.
- A4.6 Understand the contract process for issuing M&S requirements and insuring that contractor M&S is interoperable with government and other third-party M&S.
- A4.7 Understand the contractual issues involved with re-use of purchased M&S products.
- A4.8 Understand the options and procedures for enforcing contract terms or resolving contractor disputes with regard to M&S.
- A4.9 Given a case study, assess and revise contract documents to insure that program M&S objectives with regard to IP, delivery, interoperability, maintenance, and reuse are met and enforced.

11) Course learning objectives: Mastery of M&S contracting issues including IP issues, delivery and maintenance terms, reuse, interoperability, and contract enforcement.

12) Course assessment plan: Projects and Exams

13) Topic list by hour of instruction and reference:

*Competency Level: General Awareness*



- i) Hour one: (Sub ESR A4.1). Introduction and Overview (course notes and syllabus). [1]

*Competency Level: General Awareness*

- ii) Hour two: (Sub ESR A4.1). Intellectual Property Issues in Contracting for M&S products. [1]

*Competency Level: Understanding*

- iii) Hour three: (Sub ESR A4.1). Intellectual Property Issues in Contracting for M&S products. [1]

*Competency Level: General Awareness*

- iv) Hour four: (Sub ESR A4.2). Terms of Delivery and Contracting for M&S products. [2]

*Competency Level: Understanding*

- v) Hour five: (Sub ESR A4.3). Terms of Delivery and Contracting for M&S products. [2]

*Competency Level: Understanding*

- vi) Hour six: (Sub ESR A4.3). Documentation Deliverables. [3]

*Competency Level: General Awareness*

- vii) Hour seven: (Sub ESR A4.4). Long-term Maintenance for Contracted M&S products. [2]

*Competency Level: Understanding*

- viii) Hour eight: (Sub ESR A4.4). Long-term Maintenance for Contracted M&S products. [2]

*Competency Level: General Awareness*

- ix) Hour nine: (Sub ESR A4.5). Issues with using Open Architecture. [2] [4]

*Competency Level: Understanding*

- x) Hour ten: (Sub ESR A4.5). Issues with using Open Architecture. [2] [4]

*Competency Level: General Awareness*

- xi) Hour eleven: (Sub ESR A4.6). Insuring Interoperability. [4] [5]

*Competency Level: Understanding*

- xii) Hour twelve: (Sub ESR A4.6). Insuring Interoperability. [4] [5]

*Competency Level: Understanding*

- xiii) Hour thirteen: (Sub ESR A4.7). Planning for Re-use. [2]

*Competency Level: Understanding*

xiv) Hour fourteen: (Sub ESR A4.8). Enforcing M&S Contract Terms. [2]

*Competency Level: Understanding*

xv) Hour fifteen: (Sub ESR A4.9). M&S Contract Project. [2]

*Competency Level: Application*

xvi) Hour sixteen: (Sub ESR A4.9). M&S Contract Project. [2]

*Competency Level: Mastery*

xvii) Hour seventeen: (Sub ESR A4.9). M&S Contract Project. [2]

*Competency Level: Mastery*

xviii) Hour eighteen: (Sub ESR A4.9). M&S Contract Project. [2]

#### 14) Proposed references and texts:

[1] DoD Office of Acquisition Initiatives. 2001. *Intellectual Property: Navigating Through Commercial Waters*.

<http://www.acq.osd.mil/dpap/specificpolicy/intelprop.pdf>

[2] DoD. 2004. *Defense Acquisition Guidebook*. <https://akss.dau.mil/dag/>

[3] DoD. 1993. *Procedures for the Acquisition and Management of Technical Data* (5010.12-M).

[4] Department of the Navy. 2006. *Naval Open Architecture Contract Guidebook*. <https://acc.dau.mil/oa>

[5] Kuhl, F., R. Weatherly, J. Dahmann, *Creating Computer Simulation Systems: An Introduction to the High Level Architecture*. Prentice-Hall, Saddle River, NJ, 2000

## **Course Six**

**Best Practices in M&S** – This course will combine the Manage and Reuse and Best Practices in Modeling and Simulation course syllabi developed to satisfy ESRs P8 and P14 by Old Dominion University. This course will be offered both as a full academic course and as two 3-6 hour web-based courses for General Awareness, with the second course focused on M&S Reuse.

- 1) Course Name: Best Practices In Modeling and Simulation
- 2) Course coordinator: Marsha Taliaferro-Gillis, Ph.D.  
6596 Main Street  
Gloucester, VA 23061  
(804)694-3173 (Office)  
(804)824-4663 (Cell)  
mtgillis@werneranderson.com
- 3) Course description: Review of the best practices and standards in modeling and simulation. Requirements for development of best practices and standards. in modeling and simulation. Application of requirements to key case studies. VV&A reporting. Development and acquisition in M&S lifecycle.
- 4) Modules incorporated into Course - P8
- 5) **ESRs that the course supports and corresponding level of mastery.**
  - a) Best Practices in M&S Planning  
*Competency Level: General Awareness*
  - b) Best practices in M&S tool development (requirements, conceptual modeling)  
*Competency Level: General Awareness and Understanding*
  - c) Best practices in M&S federation development (DIS, HLA, IEEE standards)  
*Competency Level: General Awareness*
  - d) Best practices in software development as it applies to M&S (IEEE standards, configuration management, maturity model standards)  
*Competency Level: General Awareness and Understanding*
  - e) Best practices in VV&A (maturity model, IEEE standards)  
*Competency Level: General Awareness, Understanding, and Application*
  - f) Application of a sample M&S Support Plan to provide best use of M&S across all stages of the acquisition lifecycle  
*Competency Level: General Awareness and Application*
  - g) Analysis of a sample V&V report for inclusion in best practices in VV&A.

*Competency Level: General Awareness and Mastery*

- h) Analysis of the benefit of M&S best practices across all components of the M&S development lifecycle

*Competency Level: General Awareness and Mastery*

- i) Analysis of the benefit of M&S best practices across all components of the acquisition life-cycle.

*Competency Level: General Awareness and Mastery*

- 6) **Prerequisites assumed, and corresponding level of mastery. Mastery of College Level Calculus II and Introduction to M&S as demonstrated by a final grade of not less than a B.**

- 7) Course maturity: none

- 8) Number of contact hours and pace contemplated: 3 hours lecture/week for 8 weeks.

- 9) Proposed Delivery modality: face-to-face and/or on line.

- 10) Module learning objectives:

- P8.1 Identify best practices in M&S planning
- P8.2 Identify best practices in M&S tool development (requirements, conceptual modeling)
- P8.3 Identify best practices in M&S federation development (DIS, HLA, IEEE standards)
- P8.4 Identify best practices in software development as it applies to M&S (IEEE standards, configuration management, maturity model standards)
- P8.5 Identify best practices in VV&A (maturity model, IEEE standards)
- P8.6 Apply a sample M&S Support Plan to provide best use of M&S across all stages of the acquisition lifecycle.
- P8.7 Analyze a sample V&V report for inclusion of best practices in VV&A.
- P8.8 Given a case study, analyze the benefit of M&S best practices across all components of the M&S development lifecycle.
- P8.9 Given a case study, analyze the benefit of M&S best practices across all components of the acquisition life-cycle.

- 11) Course learning objectives: Mastery of best practices in applying federation standards, tool development, conceptual modeling, configuration management, support planning, and V&V reporting, across all components of M&S acquisition life cycle. Mastery is to be demonstrated by a grade of 85% correct on ;the final examination of 100 multiple choice questions.

- 12) Course assessment plan: final exam in a multiple choice format.

- 13) Topic list by hour of instruction and reference:

*Competency Level: General Awareness*

- i) Hour 1: (Sub ESR P8.1). Review best practices in M&S planning. [1] [2]

*Competency Level: General Awareness*

- ii) Hour 2: (Sub ESR P8.2). Learn conceptual modeling and best practices in M&S tool development. [3]

*Competency Level: General awareness*

- iii) Hour 3: (Sub ESR P8.2). Learn conceptual modeling and best practices in M&S tool development.. [3]

*Competency Level: Understanding*

- iv) Hour 4: (Sub ESR P8.2). Use conceptual modeling and best practices in developing M&S tools. [3]

*Competency Level: General Awareness*

- v) Hour 5: (Sub ESR P8.3). Learn the mechanics of developing federation standards (DIS, HLA, IEEE) for the best practices in M&S. [4] [5] [6] [7]

*Competency Level: General Awareness*

- vi) Hour 6: (Sub ESR P8.4). Learn IEEE standards, maturity model standards, configuration management, and best practices for M&S software development.. [8] [7]

*Competency Level: General awareness*

- vii) Hour 7: (Sub ESR P8.4). Learn IEEE standards, maturity model standards, configuration management, and best practices for M&S software development. [8] [7]

*Competency Level: General Awareness*

- viii) Hour 8: (Sub ESR P8.5). Learn IEEE standards and maturity models for best practices in VV&A. [9] [10]

*Competency Level: General awareness*

- ix) Hour 9: (Sub ESR P8.5). Learn IEEE standards and maturity models for best practices in VV&A. [9] [10]

*Competency Level: Understanding*

- x) Hour 10: (Sub ESR P8.5). Demonstrate best practices in using IEEE standards and maturity models for VV&A. [9] [10]

*Competency Level: Application*

- xi) Hour 11: (Sub ESR P8.5). Apply best practices in using IEEE standards and maturity models for VV&A. [9] [10]

*Competency Level: General Awareness*

- xii) Hour 12: (Sub ESR P8.6). Learn Support Planning across all stages of M&S acquisition lifecycle. [1] [2]

*Competency Level: Application*

- xiii) Hour 13: (Sub ESR P8.6). Apply Support Planning across a sample of all stages of M&S acquisition lifecycle. [1] [2]

*Competency Level...Application*

- xiv) Hour 14: (Sub ESR P8.6). Apply Support Planning across all stages of M&S acquisition lifecycle. [1] [2]

*Competency Level: General Awareness*

- xv) Hour 15: (Sub ESR P8.7). Learn the components and best practices of VV&A reporting. [9] [10]

*Competency Level: Application*

- xvi) Hour 16: (Sub ESR P8.7). Apply best practices to a sample VV&A report. [9] [10]

*Competency Level: Mastery*

- xvii) Hour 17: (Sub ESR P8.7). Analyze a sample V&V report for inclusion of best practices in VV&A. [9] [10]

*Competency Level: General Awareness*

- xviii) Hour 18: (Sub ESR P8.8). Learn the benefits best practice analysis across all components of the M&S development lifecycle. [11] [12] [13] [14]

*Competency Level: General Awareness*

- xix) Hour 19: (Sub ESR P8.8). Learn the benefits of best practice analysis across all components of the M&S development lifecycle. [11] [12] [13] [14]

*Competency Level: Understanding*

- xx) Hour 20: (Sub ESR P8.8). Use a best practice analysis across all components of a sample M&S development lifecycle. [11] [12] [13] [14]

*Competency Level: Application*

- xxi) Hour 21: (Sub ESR P8.8). Apply a best practice analysis across all components of a sample M&S development lifecycle. [11] [12] [13] [14]

*Competency Level: Mastery*

- xxii) Hour 22: (Sub ESR P8.9). Given a case study, analyze the benefit of M&S best practices across all components of the acquisition lifecycle. [11] [12] [13] [14]

*Competency Level: Mastery*

- xxiii) Hour 23: (Sub ESR P8.9). Given a case study analyze the benefits of M&S best practices across all components of the acquisition life cycle. [11] [12] [13] [14]

*Competency Level: Mastery*

- xxiv) Hour 24: (Sub ESR P8.9). Given a case study analyze the benefits of M&S best practices across all components of the acquisition life cycle. [11] [12] [13] [14]

#### 14) Proposed references and texts:

- [1] Ledin, Jim. 2001. *Simulation Engineering: Build Better Embedded systems Faster*, C M P Books, ISBN-13 9781578200801.
- [2] Bucknell University, Modeling and Simulation Best Practices for Wireless Ad Hoc. Retrieved October 24, 2007.  
<http://whitepapers.techrepublic.com.com/whitepapaer.aspx?docid=161862>
- [3] Schrage, Michael D. 1999. *Serious Play: How the World's Best Companies Simulate to Innovate*. 1999. Harvard Business School Press, Boston. ISBN 13: 9780875848143
- [4] Distributed Interactive Simulation. Doi.ieeeecs.org. Retrieved October 24,2007.  
<http://scholar.google.com/scholar?Q=author:%22Davis%22+intitle:%22A+strategy+for+c...>
- [5] High Level Architecture. Retrieved October 24, 2007.  
[http://en.wikipedia.org/wiki/High\\_Level\\_Architecture](http://en.wikipedia.org/wiki/High_Level_Architecture)
- [6] SISC Meeting 3-17-1999. [www.sisostds.org/index.php?Tg=fileman&idx=get&id=Y&path=&file=SISC\\_99\\_03\\_17\\_rev](http://www.sisostds.org/index.php?Tg=fileman&idx=get&id=Y&path=&file=SISC_99_03_17_rev). Retrieved October 24, 1007. <http://www.google.com/search?hl=en&q=HLA+Standards&btnG+Search>
- [7] IEEE LTSC WG12 Standard for Information Technology – Education and Training Systems – Learning Objects and Metadata. Itsc.ieee.org/wg12/
- [8] Law, Averill M. 2006. *Simulation Modeling and Analysis with Expertfit Software*, The McGraw-Hill Companies, Boston.
- [9] Pace, Dale K. 2004. Modeling and Simulation Verification and Validation Challenges. *Johns Hopkins APL Technical Digest*. 25(2).

- [10] Richey, Frank, 2002. Modeling and Simulation CMMI: A Conceptual View. *Cross Talk-The Journal of Defense Software Engineering*. Retrieved October 24, 2007. <http://www.stsc.hill.af.mil/crosswalk/2002/03/richey.html>
  
- [11] Murray, K. J., S.V.Sheppard. 1988. Knowledge-based simulation model specification. *Simulation*, 1988. Sim.sagepub.com. Bell Communications Research, 444 Hoes lane – RRC Piscataway, New Jersey 08854.
  
- [12] Christie, Alan M. 1999. Simulation: An Enabling Technology in Software Engineering. *Cross Talk-The Journal of Defense Software Engineering Sei.cmu.edu*. Retrieved October 24, 2007. <http://scholar.google.com/scholar?author=%22Christie%22+intitle:%22Simulation%22+An...>
  
- [13] Davis, Alan M., Bersoff, Edward H., Comer, E. R. 1988. A strategy for comparing alternative software development life cycle models. Retrieved October 24, 2007. <http://scholar.google.com/scholar?q=%22Davis%22+intitle:%22A+strategy+for+c...>
  
- [14] Bevan, Michelle T. 2001. Modeling and Simulation for Acquisition, Requirements and Training: The Army SMART Model. *The National Summit on U.S. Defense Policy: Acquisition, Research, Test and Evaluation*. IIT – Research Institute. Msia Retrieved October 24 2007.



**Course Six Continued**

- 1) Course Name: Manage and Reuse
- 2) Course coordinator: Marsha Taliaferro-Gillis, Ph.D.  
6596 Main Street  
Gloucester, VA 23061  
(804)694-3173 (Office)  
(804)824-4663 (Cell)  
mtgillis@werneranderson.com
- 3) Course description: Manage and reuse existing models, data, and simulations appropriately and assure that new products developed are designed and prepared for reuse.
- 4) Modules incorporated into Course - P14
- 5) **ESRs that the course supports and the corresponding level of mastery.**
  - a) Key concepts of M&S reuse, component-based, and distributed simulations  
Competency Level: General Awareness and Understanding
  - b) Characteristics of new simulation development that make reuse more achievable  
Competency Level: General Awareness
  - c) Sources for models that are available for reuse  
Competency Level: General Awareness
  - d) Cost versus the benefit for reuse of legacy simulations  
Competency Level: Understanding and Mastery
  - e) V&V necessary for reuse of a simulation with a new specific use  
Competency Level: General Awareness and Understanding
  - f) Models for reuse from a set of legacy models  
Competency Level: Understanding and Mastery
  - g) Cost effective options considering reuse of legacy simulations and new simulation development  
Competency Level: Understanding and Mastery
- 6) **Prerequisites assumed, and corresponding level of mastery: Mastery of College Level Calculus II and Introduction to M&S as demonstrated by a final grade of not less than a B.**

- 7) Module maturity: none
- 8) Number of contact hours and pace contemplated: 3 hours lecture/week for 6 weeks
- 9) Proposed Delivery modality: face-to-face and/or on-line
- 10) Module learning objectives:
  - P14.1 Understand key concepts for M&S reuse, component-based, and distributed simulations.
  - P14.2 Identify characteristics of new simulation development that make reuse more achievable.
  - P14.3 Identify sources for models that are available for reuse.
  - P14.4 Analyze cost versus benefit for reuse of legacy simulations.
  - P14.5 Describe V&V necessary for reuse of a simulation considering a new specific use.
  - P14.6 Given a case study and a sample of VV&A report, identify appropriate models for reuse from a set of legacy models.
  - P14.7 Given a case study and a sample of VV&A report, determine the most cost effective option considering reuse of legacy simulations and new simulation development.
- 11) Course learning objectives: Mastery of management and preparation of designs for reuse of existing data, models, and simulations. Mastery to be demonstrated by passing grades of no less than B+ on projects and exams.
- 12) Course assessment plan: projects, and exams.
- 13) Topic list by hour of instruction and reference.

*Competency Level: General Awareness*

- i) Hour 1: (Sub ESR P14.1). Learn the key concepts for M&S reuse, component-based, and distributed simulations. [1]

*Competency Level: Understanding*

- ii) Hour 2: (Sub ESR P14.1). Understand the key concepts for M&S reuse, component-based, and distributed simulations. [1]

*Competency Level: Understanding*

- iii) Hour 3: (Sub ESR P14.1). Understand the key concepts for M&S reuse, component-based, and distributed simulations. [1]

*Competency Level: General Awareness*

- iv) Hour 4: (Sub ESR P14.2). Learn the characteristics of new simulation development that make reuse more achievable. [1]

*Competency Level: General Awareness*

- v) Hour 5: (Sub ESR P14.2). Learn the characteristics of new simulation development that make reuse more achievable. [1]

*Competency Level: General Awareness*

- vi) Hour 6: (Sub ESR P14.3). Learn the sources for models that are available for reuse. [1]

*Competency Level: Understanding*

- vii) Hour 7: (Sub ESR P14.4). Understand the cost versus the benefit for reuse of legacy simulations. [2]

*Competency Level: Mastery*

- viii) Hour 8: (Sub ESR P14.4). Analyze the cost versus the benefit for reuse of legacy simulations
  - Pastor, Oscar. Juan Carlos Molina. 1998, *Model-Driven Architecture in Practice: A Software Production Environment on Conceptual Modeling*. Springer-Verlag. Berlin, Heidelberg.

*Competency Level: Mastery*

- ix) Hour 9: (Sub ESR P14.4). Analyze the cost versus the benefit for reuse of legacy simulations. [2]

*Competency Level: General Awareness*

- x) Hour 10: (Sub ESR P14.5). Learn the V&V necessary for reuse of a simulation considering a new specific use. [2]

*Competency Level: Understanding*

- xi) Hour 11: (Sub ESR P14.5). Understand the V&V necessary for reuse of a simulation considering a new specific use. [2]

*Competency Level: Understanding*

- xii) Hour 12: (Sub ESR P14.5). Understand the V&V necessary for reuse of a simulation considering a new specific use. [2]

*Competency Level: Understanding*

- xiii) Hour 13: (Sub ESR P14.6). Given a case study and a sample of a VV&A report, identify the appropriate models for reuse from a set of legacy models. [2]

*Competency Level: Mastery*

- xiv) Hour 14: (Sub ESR P14.6). Given a case study and a sample of a VV&A report, analyze the appropriate models for reuse from a set of legacy models. [2]

*Competency Level: Mastery*

- xv) Hour 15: (Sub ESR P14.6). Given a case study and a sample of a VV&A report, analyze the appropriate models for reuse from a set of legacy models. [2]

*Competency Level: Understanding*

- xvi) Hour 16: (Sub ESR P14.7). Given a case study and a sample of a VV&A report, understand the most cost effective option considering reuse of legacy simulations and new simulation development. [3]

*Competency Level: Mastery*

- xvii) Hour 17: (Sub ESR P14.7). Given a case study and a sample of a VV&A report, analyze the most cost effective option considering reuse of legacy simulations and new simulation development. [3]

*Competency Level: Mastery*

- xviii) Hour 18: (Sub ESR P14.7). Given a case study and a sample of a VV&A report, analyze the most cost effective option considering reuse of legacy simulations and new simulation development. [3]

14) Proposed references and texts:

- [1] Rombach, H. D., Victor R. Basili, Richard W. Selby. 1993 *Experimental Software Engineering Issues*. Springer-Verlag. Berlin, Heidelberg.
- [2] Pastor, Oscar. Juan Carlos Molina. 1998, *Model-Driven Architecture in Practice: A Software Production Environment on Conceptual Modeling*. Springer-Verlag. Berlin, Heidelberg.
- [3] Zeigler, Bernard P., [Tag Gon Kim](#), [Herbert Praehofer](#). 2000. *Theory of Modeling and Simulation*. Academic Press. San Diego CA.

## **Course Seven**

**M&S in Decision Risk Analysis and Risk Mitigation** - This course will be modeled after the M&S in Decision Risk Analysis and Risk Mitigation course syllabi developed to satisfy ESRs A7 and P6 (partial) by University of California, San Diego. This course will be offered both as a full academic course and as a 3-6 hour web-based course for General Awareness.

- 1) Course Name: M&S in Decision Risk Analysis and Risk Mitigation
- 2) Course coordinator/POC: Anthony Genna  
UCSD Extension  
Assistant Director,  
Defense Technology  
agenna@ucsd.edu  
858-603-2170 (cell)
- 3) Course description: This course is designed to educate and introduce acquisition workforce professionals to modeling and simulation (M&S) and its application to Decision Risk Analysis and Risk Mitigation. This course will introduce the student to the concepts entailed in the use of M&S to make informed engineering tradeoff analyses through the program's Decision Risk Analysis process. General focus areas of this course include: application of experimental design, level of model detail, risk mitigation strategy development, evaluation of M&S outputs/measures, and M&S application as a pre-test prediction tool.
- 4) Modules incorporated into the course: A7, limited/modified P6.
- 5) ESR's that the course supports and the corresponding level of achievement:
  - A7.1 (G, U, A, M)
  - A7.2 (G, U, A, M)
  - A7.3 (G, U, A, M)
  - A7.4 (G, U, A, M)
  - A7.5 (G, U, A, M)
  - P6.6 (G, U, A, M)
- 6) Prerequisites: This course is designed for DoD military and civilian professionals who are determined to be proficient to the apprentice, journeyman or expert level (as applicable) in their current job positions in the areas of program management, systems engineering and/or test and evaluation.
- 7) Course maturity: This is a new course. There is a 5-day course on Decision and Risk Analysis (SYS/SDOE 660) available from Stevens Institute of Technology, but it presents the core topics differently than this course does.

8) Number of contact hours and pace contemplated: This 27 hour course will provide 3 CEU's. The class will meet 3 hours per week for 9 weeks. The hour breakdown for each level of competency is provided below:

- a) General Awareness 3 hours
- b) Understanding 4 hours
- c) Application 9 hours (5 hr instruction; 3 hr project; 1 hr exam)
- d) Mastery 11 hours (7 hr instruction; 3 hr project; 1 hr exam)

9) Proposed delivery modality: face-to-face.

10) Proposed references and texts:

[1] Risk Assessment and Decision Making in Business and Industry: a Practical Guide, by Glenn Koller, CRC Press, Boca Raton, Florida, 1999.

[2] Risk Management Guide for DoD Acquisition, 6<sup>th</sup> ed., V1.0, August 2006.

<http://www.sei.cmu.edu/risk/dod-risk.pdf>

Additional useful references:

[3] OPNAVINST 5200.34, Navy Modeling and Simulation (M&S) Management, 28 May 2002.

[4] Simulation Based Acquisition: A New Approach, Report of the Military Research Fellows, DSMC, 1997-1998.

11) Course learning objectives:

A7.1: Develop pre-test criteria and analyze/apply choices of design detail for desired performance factors for a selected application.

A7.2: Analyze outputs/measures from M&S tools for a given case study.

A7.3: Evaluate performance factors and interdependencies of outputs/measures based on a given set of case studies.

A7.4: Identify and prioritize risk factors using the Decision Risk Analysis process.

P6.6: Develop a risk mitigation strategy for a given case study.

A7.5: Perform informed engineering tradeoff analyses through the Decision Risk Analysis process.

12) Course assessment plan:

- a) Week 1 through week 9: Weekly quizzes to test competency at corresponding level of instruction.

- b) Week 5: Class project based on case study to demonstrate students' ability to perform analysis at the application level.
- c) Week 6: Mid term exam to test student competency at the application level.
- d) Week 9: Class project based on case study to demonstrate students' ability to perform analysis and evaluation at the mastery level.
- e) Week 9: Case study and final exam to test student's ability to perform analysis and evaluation at the mastery level.

13) Topic list by hour of instruction and reference:

The 27 hour course is structured such that each hour is based on its required level of competency. This structure allows the course material to be provided as four separate groupings: General Awareness, Understanding, Application, and Mastery.

General Awareness Skill Level:

- 1-3 Introduction and overview of informed engineering tradeoff analyses using a Decision Risk Analysis process. A7.1-A7.5, P6.6. Ref: [1], [2], instructor notes.

Understanding Skill Level:

- 4 Definition of pre-test criteria and application of design detail choices for desired performance factors for a selected application. A7.1. Ref: [1], [2], instructor notes.
- 5 Identification of outputs/measures, interdependencies and performance factors related to M&S tools. A7.2, A7.3. Ref: [1], [2], instructor notes.
- 6 Identification and prioritization of risk factors using a Decision Risk Analysis process. Identify critical elements required to develop exceptional system risk mitigation strategies. A7.4, P6.6. Ref: [1], [2], instructor notes.
- 7 Examples of how a Decision Risk Analysis process enables informed engineering tradeoff analysis. A7.5. Ref: [1], [2], instructor notes.

Application Skill Level:

- 8 Use of M&S applications to develop pre-test criteria and analyze/apply choices of design detail for desired performance factors for a selected application. A7.1. Ref: [1], [2], instructor notes.
- 9 Use of M&S applications to analyze outputs/measures from M&S tools for a given case study. A7.2. Ref: [1], [2], instructor notes.
- 10 Use of M&S applications to evaluate performance factors and interdependencies of outputs/measures for a given case study. A7.3. Ref: [1], [2], instructor notes.
- 11 Use of M&S applications to identify and prioritize risk factors using a Decision Risk Analysis process. A7.4. Ref: [1], [2], instructor notes.
- 12 Use of M&S application techniques that support risk mitigation. P6.6. Ref: [1], [2], instructor notes.

- 13-15 Class team project: Perform informed engineering tradeoff analyses through a Decision Risk Analysis process. Apply modeling and simulation techniques to risk analysis and risk mitigation. A7.5. Ref: [1], [2], instructor notes.
- 16 Mid term exam to evaluate student competency at the application level. Ref: [1], [2], instructor notes.

*Mastery Skill Level:*

- 17-18 Use of M&S tools to support analysis and application of choices of design detail for desired performance factors. Includes instructor-selected case studies. A7.1. Ref: [1], [2], instructor notes.
- 19 Use of M&S tools in support of analysis of M&S outputs/measures. Includes instructor-selected case studies. A7.2. Ref: [1], [2], instructor notes.
- 20-21 Use of M&S tools in support of analysis and evaluation of performance factors and interdependencies of outputs/measures for a given case study. A7.3. Ref: [1], [2], instructor notes.
- 22-23 Use of M&S tools to identify and prioritize risk factors using a Decision Risk Analysis process. A7.4. Ref: [1], [2], instructor notes.
- 24 Use of M&S application techniques that support risk mitigation. P6.6. Ref: [1], [2], instructor notes.
- 25-26 Class team project: Evaluation of informed engineering tradeoff analyses through a Decision Risk Analysis process. Includes instructor-selected case studies. A7.5. Ref: [1], [2], instructor notes.
- 27 Final exam to test student's ability to perform analysis and evaluation at the mastery level. Ref: [1], [2], instructor notes.



## **Course Eight**

**M&S Environments** – This course will be modeled after the ISE 5X5 M&S Environments in Acquisition course syllabus developed to satisfy ESR P14 by the University of Alabama at Huntsville. This course will be offered both as a full academic course and as a 3-6 hour web-based course for General Awareness.

1) Course Name : ISE 5X5 M&S Environments for Acquisition

2) Course coordinator

Dr. Mikel D. Petty, 256-824-4368, pettym@uah.edu

3) Course description

Architectures and attributes of modeling and simulation environments (live, virtual, constructive) and interoperability approaches (standalone, interoperable). Focus is on their application and suitability for testing and acquisition applications.

4) Modules incorporated into course

P4-G M&S environments and interoperability (General awareness)

P4-U M&S environments and interoperability (Understanding)

P4-A M&S environments and interoperability (Application)

P4-M M&S environments and interoperability (Mastery)

5) ESRs that the course supports and the corresponding level of mastery

ESR P4 General awareness, Understanding, Application, and Mastery

6) Prerequisites assumed, and corresponding level of mastery

Basic familiarity with M&S concepts, equivalent to MSIAC M&S Staff Officers Course

7) Course maturity

Not previously taught as a course; much of the material has been taught in other courses, particularly Old Dominion University's MSIM 601 course and in Certified Modeling and Simulation Professional examination preparation courses.

8) Number of contact hours and pace contemplated

Semester course: 3 lecture hours per week for 16 weeks

9) Proposed delivery modality

Face-to-face lecture, synchronous distance learning (live audio/video connection), asynchronous distance learning (web or CD)

10) Proposed references and texts

[1] R. M. Fujimoto, "Distributed Simulation and the High Level Architecture", in W. B. Rouse and K. R. Boff (Editors), *Organizational Simulation*, John Wiley & Sons, Hoboken NJ, 2005, pp. 591-609.

[2] R. M. Fujimoto, "Parallel and Distributed Simulation", in J. Banks (Editor),

*Handbook of Simulation*, John Wiley & Sons, New York 1998, pp. 429-464.

[3] M. Petty, MSIM 601 and CMSP Exam Prep lecture notes.

[4] O. Balci, "Verification, Validation, and Testing", in J. Banks (Editor), *Handbook of Simulation*, John Wiley & Sons, New York 1998, pp. 335-393.

[5] J. A. Sokolowski and C. M. Banks, *Principles of Modeling and Simulation: A Multidisciplinary Approach*, Wiley, New York NY, 2008.

#### 11) Course learning objectives

Correspond to sub-ESRs for ESR P4

- a) P4.1 Define the different testing environments (live, virtual, and constructive) and compare the relative advantages and disadvantages of each environment for different product and system testing applications.
- b) P4.2 Identify the attributes of an M&S application that determine whether a live, virtual, constructive, or combination environment would be most appropriate, and the values for those attributes that indicate each type.
- c) P4.3 List significant and widely used models, standalone simulations, confederated simulations, data sets, and interoperability protocol standards applied in the different environments.
- d) P4.4 Describe approaches to testing and validating models and simulations suitable for use in each of the environments, and identify degree of accuracy typically required in that environment.
- e) P4.5 Define the differences between standalone and federated simulation and give examples of each that have been used successfully in test and acquisition applications. Identify the attributes of an M&S application that determine whether a standalone simulation or a federation of interoperable simulations would be more appropriate, and the values for those attributes that indicate each type.
- f) P4.6 List current simulation interoperability protocol standards and describe the advantages and disadvantages of each in each of the different environments.
- g) P4.7 List existing resources in each of the environments, including model repositories, implemented federations of interoperable simulations, standalone simulations, standard object models, and accredited data sets, and describe the procedures for searching for resources within repositories of them.
- h) P4.8 Describe case studies of successful test and acquisition M&S applications in each of the different environments.

#### 12) Course assessment plan

1. Mid-term and final exams
2. Short-answer homework assignments, ~1 per week
3. Term paper

#### 13) Topic list by hour of instruction and reference

Listed for each hour are topic description, related sub-ESR, and reference (if any).

1. Basic concepts, definitions, and examples of live, virtual, and constructive environments; P4.1; [1] [2] [3]
2. Basic concepts, definitions, and examples of M&S application attributes; P4.2; [4]

3. Basic concepts, definitions, and examples of categories (models, standalone simulations, interoperable simulations, data sets, and interoperability protocol standards) within live, virtual, and constructive environments; P4.3; ; [1] [2] [3]
4. Basic concepts, definitions, and examples of testing and validation in live, virtual, and constructive environments; P4.4; [4]
5. Basic concepts, definitions, and examples of standalone and interoperable simulations; P4.5; ; [1] [2] [3]
6. Basic concepts, definitions, and examples of interoperability protocol standards; P4.6; [1] [2] [3]
7. Basic concepts, definitions, and examples of each type of existing resource in live, virtual, and constructive environments; P4.7; to be determined
8. Simple case studies of successful test and acquisition M&S applications; P4.8; to be determined
9. Typical product and system testing applications and advantages and disadvantages of live, virtual, and constructive environments for each; P4.1; [3]
10. Typical live, virtual, and constructive environment architectures; P4.1; [3]
11. Attributes of M&S applications typically found in live, virtual, and constructive environments; P4.2; [3]
12. Lists of significant and widely used items in each category and explanations for their significance live, virtual, and constructive environments; P4.3; to be determined
13. Details of different testing and validation methods used in live, virtual, and constructive environments; P4.4; [4]
14. Differences and advantages/disadvantages of standalone and interoperable simulations; P4.5; [1] [2] [3] [4]
15. Examples of successful use of standalone and interoperable simulations for test and acquisition applications; P4.5; to be determined
16. Technical details of current interoperability protocol standards; P4.6; [1] [2] [3]
17. Relative capabilities and typical applications of current interoperability protocol standards in live, virtual, and constructive environments; P4.6; [1] [2] [3]
18. Lists and details of existing resources in live, virtual, and constructive environments; P4.7; to be determined
19. Resource repositories in live, virtual, and constructive environments; P4.7; to be determined
20. Advanced case studies of both successful and unsuccessful test and acquisition M&S applications; P4.8; to be determined
21. Customizing live, virtual, and constructive environments for a specific application; P4.1; [1] [2] [3]
22. Determining the attributes of given M&S applications in live, virtual, and constructive environments; P4.2; to be determined
23. M&S application attributes in unusual applications and special cases; P4.2; to be determined
24. Recognizing significant, or potentially significant, items in live, virtual, and constructive environments; P4.3; to be determined
25. Performing testing and validation using existing methods in live, virtual, and constructive environments; P4.4; [4]

26. Applying standalone and interoperable simulations in test and acquisition M&S applications; P4.5; [1] [2] [3]
27. Attributes of M&S applications that determine whether a standalone or interoperable simulation would be more appropriate, and attribute values that indicate each type; P4.5; [1] [2] [3]
28. Applying interoperability protocol standards in test and acquisition M&S applications; P4.6; [1] [2] [3]
29. Procedures for examining, acquiring, customizing, and using existing resources; P4.7; to be determined
30. Adapting methods and lessons from a case study to a new test and acquisition M&S application; P4.8; to be determined
31. Analyzing a test and acquisition M&S application for lessons learned; P4.8; to be determined
32. Selecting among live, virtual, and constructive environments for a specific application based on environment characteristics; P4.1; [1] [2] [3]
33. Designing and integrating hybrid live, virtual, and constructive environments for specialized applications; P4.1; [1] [2] [3]
34. Selecting among live, virtual, and constructive environments based on M&S application attributes; P4.2; [1] [2] [3]
35. Selecting among available widely used items for an application within live, virtual, and constructive environments; P4.3; [1] [2] [3]
36. Selecting appropriate testing and validation methods in live, virtual, and constructive environments; P4.4; [4]
37. Developing new, enhanced, or hybrid environment-specific testing and validation methods in live, virtual, and constructive environments; P4.4; to be determined
38. Selecting among standalone and interoperable simulations based on the attributes of an M&S application; P4.5; [1] [2] [3]
39. Selecting among current interoperability protocol standards for a given M&S application in live, virtual, and constructive environments; P4.6; [1] [2] [3]
40. Selecting among existing resources for use in test and acquisition M&S application in live, virtual, and constructive environments; P4.7; to be determined
41. Selecting a case study relevant to a planned test and acquisition M&S application and extracting pertinent lessons learned; P4.8; to be determine

## **Course Nine**

**M&S Data Strategies** – This course will be modeled after the ISE 5X7 M&S Data Strategies for Acquisition course syllabus developed to satisfy ESR P15 by the University of Alabama at Huntsville. This course will be offered both as a full academic course and as a 3-6 hour web-based course for General Awareness.

- 1) Course Name: ISE 5X7 M&S Data Strategies for Acquisition
- 2) Course coordinator  
Dr. Mikel D. Petty, 256-824-4368, pettym@uah.edu
- 3) Course description  
Categories, uses, formats, and models of data for modeling and simulation. Acquiring, converting, preparing, controlling, securing, and distributing data. Focus is on their application and suitability for testing and acquisition applications.
- 4) Modules incorporated into course  
P15-G Data strategy (General awareness)  
P15-U Data strategy (Understanding)  
P15-A Data strategy (Application)  
P15-M Data strategy (Mastery)  
plus portions of P10 M&S in the acquisition process
- 5) ESRs that the course supports and the corresponding level of mastery  
ESR P15 General Awareness, Understanding, Application, and Mastery
- 6) Prerequisites assumed, and corresponding level of mastery  
Basic familiarity with M&S concepts, equivalent to MSIAC M&S Staff Officers Course
- 7) Course maturity  
Not previously taught as a course; much of the material has been taught in other courses, particularly Old Dominion University's MSIM 601 course and in Certified Modeling and Simulation Professional examination preparation courses.
- 8) Number of contact hours and pace contemplated  
Semester course: 3 lecture hours per week for 16 weeks
- 9) Proposed delivery modality  
Face-to-face lecture, synchronous distance learning (live audio/video connection), asynchronous distance learning (web or CD)
- 10) Proposed references and texts  
[1] S. Adelman, L. Moss, and M. Abai, *Data Strategy*, Addison-Wesley, 2005.

[2] B. P. Zeigler and P. E. Hammonds, *Modeling and Simulation-Based Data Engineering: Introducing Pragmatics into Ontologies for Net-Centric Information Exchange*, Academic Press, 2007.

#### 11) Course learning objectives

Correspond to sub-ESRs for ESR P14

- a) P15.1 List the categories of data sets required (such as terrain databases, Ph/Pk tables, and sensor performance parameters) for typical model and simulation types.
- b) P15.2 List the data requirements for typical test and acquisition M&S applications in terms of data sets, data volume, data availability, data accuracy, data classification, data storage media, and data archival.
- c) P15.3 Identify existing data resources available for reuse, including both unauthenticated (for simulation testing) and authenticated (for actual test use) data, and describe the procedures for searching for resources within repositories of them.
- d) P15.4 Define commonly used formats for documenting data (i.e., meta-data) and describe how to use each form to assess a data set's utility for a specific application.
- e) P15.5 For each type of data used by models and simulations, define commonly used formats for structuring and encoding the data (e.g., XML for entity performance parameters or CTDB for terrain) and describe how the format supports correct and appropriate use and reuse of data sets so structured.
- f) P15.6 Define concepts of data models (e.g., HLA object models), identify commonly used data models (e.g., HLA RPR FOM), and explain how data models relate to data sets.
- g) P15.7 Specify proper security procedures for safeguarding classified data sets, both input and output, during and between simulation executions.
- h) P15.8 Prepare for distribution of output data sets produced by simulation executions, including documenting data format, assumptions, accuracy, and applicability.
- i) P15.9 Describe approaches, identify tools, and estimate resources required for converting data sets from one format to another (e.g., converting terrain data from DTED to CTDB) if needed for a particular M&S application.
- j) P15.10 Estimate the effort required to acquire and create the data needed for a test or acquisition M&S application, based on data required for the simulation, existing data resources available, and data creation experiences.
- k) P15.11 Describe case studies of successful data acquisition and creation for data-intensive applications of commonly used models, data sets, and simulations, and the characteristics of those applications that made the reuse successful.

#### 12) Course assessment plan

4. Mid-term and final exams
5. Short-answer homework assignments, ~1 per week
6. Term paper

#### 13) Topic list by hour of instruction and reference

Listed for each hour are topic description, related sub-ESR, and reference (if any).

1. Identify the phases of the acquisition life cycle; P10.1; to be determined
2. Identify the principal M&S applications used in each of the phases of the acquisition life cycle; P10.2; to be determined

3. Describe representative examples of M&S used for each type of application in each phase of the acquisition life cycle; P10.3; to be determined
4. List the inputs, outputs, capabilities, and limitations of each example M&S; P10.4; to be determined
5. Basic concepts, definitions, and examples of data set categories (e.g., terrain databases, Ph/Pk tables, and sensor performance parameters) required for typical model and simulation types; P15.1; to be determined
6. Basic concepts, definitions, and examples of data requirements for typical test and acquisition M&S applications; P15.2; to be determined
7. Basic concepts, definitions, and examples of each type of existing data resource; P15.3; to be determined
8. Basic concepts, definitions, and examples of data documentation formats; P15.4; [1] [2]
9. Basic concepts, definitions, and examples of data encoding formats; P15.5; [1] [2]
10. Basic concepts, definitions, and examples of data models; P15.6; [1] [2]
11. Basic concepts, definitions, and examples of data security procedures; P15.7; [1] [2]
12. Basic concepts, definitions, and examples of simulation data distribution; P15.8; [2]
13. Basic concepts, definitions, and examples of data conversion; P15.9; [1] [2]
14. Basic concepts, definitions, and examples of data acquisition and creation effort; P15.10; to be determined
15. Simple case studies of successful data acquisition and creation in test and acquisition M&S applications; P15.11; to be determined
16. Technical details of simulation data sets, including representation, resolution, fidelity, and size, for typical model and simulation types; P15.1; [2]
17. Technical details and normal value ranges of data requirement parameters (e.g., data sets, data volume, data availability, data accuracy, data classification, data storage media, data archival; P15.2; .[2]
18. Lists and details of existing data repositories; P15.3; to be determined
19. Technical details and advanced examples of data documentation formats; P15.4; [1] [2]
20. Technical details and advanced examples of data encoding formats; P15.5; [1] [2]
21. Technical details and advanced examples of data models; P15.6; [1] [2]
22. Relationship of data models to data sets; P15.6; [1] [2]
23. Data security requirements and procedures; P15.7; to be determined
24. Advanced examples of data security in test and acquisition M&S applications; P15.7; to be determined
25. Advanced examples of data distribution in test and acquisition M&S applications; P15.8; to be determined
26. Advanced examples of data conversion for test and acquisition M&S applications; P15.9; to be determined
27. Available data conversion tools and utilities; P15.9; to be determined
28. Advanced examples of data acquisition and creation effort in test and acquisition M&S applications; P15.10; to be determined
29. Advanced case studies of both successful and unsuccessful data acquisition and creation in test and acquisition M&S applications; P15.11; to be determined
30. Determining data set categories for typical model and simulation types; P15.1; [2]

31. Determining data requirements for typical test and acquisition M&S applications; P15.2; [2]
32. Procedures for examining, acquiring, customizing, and reusing existing data resources; P15.3; to be determined
33. Using data documentation in each format to evaluate data utility; P15.4; [1] [2]
34. Using data encoding formats to encode or decode simulation data; P15.5; [1] [2]
35. Using data models to structure and organize data within a test and acquisition M&S application; P15.6; [1] [2]
36. Instituting and executing data security in test and acquisition M&S applications; P15.7; to be determined
37. Performing data distribution in test and acquisition M&S applications; P15.8; to be determined
38. Performing data conversion for test and acquisition M&S applications; P15.9; to be determined
39. Effects of data conversion on data resolution and accuracy; P15.9; to be determined
40. Estimating effort required for data acquisition and creation in test and acquisition M&S applications; P15.10; to be determined
41. Adapting methods and lessons regarding data acquisition and creation from a case study to a new test and acquisition M&S application; P15.11; to be determined
42. Analyzing a test and acquisition M&S application for lessons learned regarding data acquisition and creation; P15.11; to be determined
43. Selecting among data acquisition and creation alternatives; P15.10; [1] [2]
44. Selecting a case study relevant to data acquisition and creation in a planned test and acquisition M&S application and extracting pertinent lessons learned; P15.11; to be determined



## **Course Ten**

**M&S for Test and Evaluation, Introduction and Advanced** – These courses will be modeled after the ISE 5X1 Introduction to Modeling and Simulation for T&E and ISE 5X2 Advanced Modeling and Simulation for T&E course syllabi developed to satisfy ESRs T1 through T5 by the University of Alabama at Huntsville. These courses will each be offered both as a full academic course and as 3-6 hour web-based courses for General Awareness.

- 1) Course Name ISE 5X1 Introduction to Modeling and Simulation for T&E
- 2) Course coordinator / point of contact and contact information  
 Dr. Jeffrey S. Strickland, UAH CMSA, 256-824-4415, [jeffrey.strickland@uah.edu](mailto:jeffrey.strickland@uah.edu)  
 Dr. Mikel D. Petty, UAH CMSA, 256-824-4368, [pettym@uah.edu](mailto:pettym@uah.edu).
- 3) Course description This course will address the use of modeling and simulation as a complement to physical testing in support of systems evaluation. The general relationships among simulation, test, and evaluation will be introduced in context of systems acquisition life-cycle management. Forms of use of simulation in support of test planning, test execution, and systems analysis will be described, characterized, and illustrated with real-world examples. Issues and opportunities relevant to the integrated use of simulation and testing will be identified; and strategies to optimize the use of scarce resources in executing test and evaluation programs will be provided.
- 4) Modules incorporated into Course T1-G, T1-U, T2-G, T2-U, T3-G, T3-U, T4-G, T4-U, T5-G, and T5-U
- 5) ESRs that the course supports and the corresponding level of mastery
  - a) ESR T-1 General Awareness and Understanding
  - b) ESR T-2 General Awareness and Understanding
  - c) ESR T-3 General Awareness and Understanding
  - d) ESR T-4 General Awareness and Understanding
  - e) ESR T-5 General Awareness and Understanding
- 6) Prerequisites assumed, and corresponding level of mastery ISE 428 - Systems Analysis and Design I; ISE 447/547 - Introduction to Systems Simulation
- 7) Course maturity Not previously taught
- 8) Number of contact hours and pace contemplated 3 hours lecture/week for 16 week.
- 9) Proposed Delivery modality: Resident (face-to-face)
- 10) Proposed references and texts

- [1] Systems Engineering Principles and Practice, by Alexander Kossiakoff and William N. Sweet, NY: Wiley, 2003
- [2] Department of the Army Pamphlet 73-1: Test and Evaluation in Support of Systems Acquisition, Headquarters, Department of the Army, Washington, DC, 30 May 2003.

11) Course learning objectives

- a) Identify and apply DoD policies and regulations related to M&S for T&E [T1]
- b) Identify types of M&S, uses and benefits, and limitations and risks for T&E [T1, T2]
- c) Identify the uses of M&S during Developmental T&E (DT&E), Operational T&E (OT&E), and Live Fire T&E [T3]
- d) Identify the uses of M&S for testing in a joint environment [T3]
- e) Describe the process and importance of M&S Validation, Verification, & Accreditation [T2]
- f) Describe the M&S program contractual process [T4]
- g) Match existing M&S T&E facilities used within the DoD to a given program need, as appropriate [T5]

12) Course assessment plan five module exams, course average to pass is 80%.

13) Topic list by hour of instruction and reference

- i) Introduction and overview (course notes and syllabus)
- ii) Roles, uses, limitations and trends of models and simulations of various types; T1.1; [2]
- iii) Use of M&S in systems engineering and decision support for T&E; T1.2; [2]
- iv) Use of M&S in a system's lifecycle for all phases of test and evaluation; T1.3; [1] [2]
- v) Appropriate simulation use and model fidelity for systems validation; T1.4; [2]
- vi) Restrictions, applications, limitations, and risk of using M&S during T&E; T1.5; [2]
  - (1) Risks of using M&S in evaluating a single system component in place of testing an entire configuration.
  - (2) In conjunction with/in place of live testing
- vii) Use of M&S in test planning; T1.6; [2]
- viii) Levels of risk in testing (Risk and Its Impact on VV&A, Recommended Practices Guide); T1.7 T1.8
  - (1) the application of M&S in risk reduction
  - (2) Acceptable risk involving the use of M&S in testing
- ix) Use of M&S for risk analysis and mitigation; T1.9; [2]
- x) Module exam (course notes)
- xi) Introduction and overview (course notes and syllabus)
- xii) Types of simulation used in T&E; T2.1; [2]

- xiii) Using the Data Source Matrix (DSM) to describe T&E events and simulation events; T2.2; [2]
- xiv) Appropriate use of M&S in T&E; T2.3; [2]
- xv) Data arising from live and virtual testing; T2.4; [2]
- xvi) Use of M&S in developing test scenarios and data matrices; T2.5; [2]
- xvii) Examples of M&S integrated with T&E; T2.6 T2.7; [2]
- xviii) Model-Test-Model methodology; T2.8; [2]
- xix) Issues and opportunities relevant to the integrated use of M&S in testing T2.9; [2]
- xx) Integrating results of M&S with results from other sources of T&E; T2.10; [2]
- xxi) Module exam (course notes)
- xxii) Introduction and overview (course notes and syllabus)
- xxiii) Use of M&S in evolutionary test process; T3.1; [2] and Testing of Defense Systems in an Evolutionary Acquisition Environment).
- xxiv) Role of M&S in integration testing; T3.2; [2]
- xxv) Role of M&S in developmental testing; T3.3; [2]
- xxvi) Role of M&S in operational testing; T3.4; [2]
- xxvii) Role of M&S in unit testing; T3.5; [2]
- xxviii) Role of M&S in interoperability testing; T3.7; [2]
- xxix) Role of M&S in live fire testing; T3.6; [2]
- xxx) Interrelationships between M&S and traditional forms of T&E; T3.8; [2] [1]
- xxxi) Test procedures for various types of testing; T3.9; [2]
- xxxii) Module exam (course notes)
- xxxiii) Introduction and overview (course notes and syllabus)
- xxxiv) M&S and the Test and Evaluation Master Plan (TEMP); T4.1; [2]
- xxxv) M&S and the System Evaluation Plan (SEP); T4.2; [2]
- xxxvi) The Test/Simulation Execution Strategy (T/SES); T4.2; [2]
- xxxvii) Programmatic for M&S in T&E; T4.3; [2]
- xxxviii) M&S in test planning, test execution, and systems analysis; T4.4 T4.5 T4.6; [2]
- xxxix) M&S life-cycle costs in T&E; T4.7; [2]
- xl) Module exam (course notes)
- xli) Key facilities which support DoD M&S T&E (including Major Shared Resource Centers).
- xl ii) Missions of the key facilities which support DoD M&S T&E.
- xl iii) Principle DoD customers to the key facilities which support DoD M&S T&E.
- xl iv) Current capabilities (strengths and weaknesses) of the key facilities which support DoD M&S T&E.
- xl v) Improvement and modernization activities of the key facilities which support DoD M&S T&E.
- xl vi) Emerging facilities (currently under development) which will support DoD M&S T&E.
- xl vii) Module exam (course notes)

xlvi) Course review and feedback

## **Course Eleven**

- 1) Course Name: ISE 5X2 Advanced Modeling and Simulation for T&E
- 2) Course coordinator / point of contact and contact information:  
 Dr. Jeffrey S. Strickland, UAH CMSA, 256-824-4415, [jeffrey.strickland@uah.edu](mailto:jeffrey.strickland@uah.edu)  
 Dr. Mikel D. Petty, UAH CMSA, 256-824-4368, [pettym@uah](mailto:pettym@uah)
- 3) Course description: This course is a follow-on from ISE 5X2. The will address the application of modeling and simulation as a complement to physical testing in support of systems evaluation. The general relationships among simulation, test, and evaluation will be further investigated in context of systems acquisition life-cycle management. Forms of use of simulation in support of test planning, test execution, and systems analysis will be described, characterized, and illustrated with real-world examples. Issues and opportunities relevant to the integrated use of simulation and testing will be identified; and strategies to optimize the use of scarce resources in executing test and evaluation programs will be provided.
- 4) Modules incorporated into Course: T1-A, T1-M, T2-A, T2-M, T3-A, T3-M, T4-A, T4-M, T5-A, and T5-M
- 5) ESRs that the course supports and the corresponding level of mastery.
  - a) ESR T-1 Application and Mastery
  - b) ESR T-2 Application and Mastery
  - c) ESR T-3 Application and Mastery
  - d) ESR T-4 Application and Mastery
  - e) ESR T-5 Application and Mastery
- 6) Prerequisites assumed, and corresponding level of mastery. ISE 5X1 - Introduction to Modeling and Simulation for T&E
- 7) Course maturity: Not previously taught
- 8) Number of contact hours and pace contemplated: 3 hours lecture/week for 16 week.
- 9) Proposed Delivery modality: Resident (face-to-face)
- 10) Proposed references and texts:
  - [1] Systems Engineering Principles and Practice, by Alexander Kossiakoff and William N. Sweet, NY: Wiley, 2003
  - [2] Systems Analysis, Design, and Development, by Charles Wasson, NY: Wiley, 2006
  - [3] Department of the Army Pamphlet 73-1: Test and Evaluation in Support of Systems Acquisition, Headquarters, Department of the Army, Washington, DC, 30

May 2003.

11) Course learning objectives:

- a) Apply DoD policies and regulations related to M&S for T&E [T1]
- b) Describe types of M&S, uses and benefits, and limitations and risks for T&E [T1, T2]
- c) Describe the uses of M&S during Developmental T&E (DT&E), Operational T&E (OT&E), and Live Fire T&E [T3]
- d) Evaluate the uses of M&S for testing in a joint environment [T3]
- e) Describe the process and importance of M&S Validation, Verification, & Accreditation [T2]
- f) Demonstrate the M&S program contractual process [T4]  
Match existing M&S T&E facilities used within the DoD to a given program need, as appropriate [T5]

12) Course Assessment Plan four module case studies and a final exam, course average to pass is 80%

13) Topic list by hour of instruction and reference.

- i) Introduction and overview (course notes and syllabus)
- ii) Use of M&S in a system's lifecycle for all phases of test and evaluation; T1.3; [1]
- iii) Appropriate simulation use and model fidelity for systems validation; T1.4 [3]
- iv) Restrictions, applications, limitations, and risk of using M&S during T&E; T1.5; [3]
- v) Use of M&S in open systems testing; T1.6; [1]
- vi) Levels of risk/and risk reduction using M&S in testing (Risk and Its Impact on VV&A, Recommended Practices Guide); T1.7
- vii) Module case study (course notes)
- viii) Module case study, continued (course notes)
- ix) Introduction and overview (course notes and syllabus)
- x) Using the Data Source Matrix (DSM) to describe T&E events and simulation events; T2.2; [3]
- xi) Appropriate use of M&S in T&E; T2.3; [3]
- xii) Data arising from live and virtual testing; T2.4; [3]
- xiii) Use of M&S in developing test scenarios and data matrices; T2.5; [3]
- xiv) Examples of M&S integrated with T&E; T2.6 T2.7; [3]
- xv) Model-Test-Model methodology; T2.8; [3]
- xvi) Issues and opportunities relevant to the integrated use of M&S in testing; T2.9; [3]
- xvii) Integrating results of M&S with results from other sources of T&E; T2.10; [3]
- xviii) Module case study (course notes)
- xix) Module case study, continued (course notes)
- xx) Introduction and overview (course notes and syllabus)

- xxi) Use of M&S in evolutionary test process; T3.1; [3] and Testing of Defense Systems in an Evolutionary Acquisition Environment).
- xxii) Role of M&S in integration testing; T3.2; [1] [3]
- xxiii) Role of M&S in developmental testing; T3.3; [1] [3]
- xxiv) Role of M&S in operational testing; T3.4; [1] [3]
- xxv) Role of M&S in unit testing; T3.5; [1] [3]
- xxvi) Role of M&S in interoperability testing; T3.7; [1] [3]
- xxvii) Role of M&S in live fire testing; T3.6; [3]
- xxviii) Interrelationships between M&S and traditional forms of T&E; T3.8; [3] [2]
- xxix) Test procedures for various types of testing; T3.9; [1] [3]
- xxx) Module case study (course notes)
- xxxi) Module case study, continued (course notes)
- xxxii) Introduction and overview (course notes and syllabus)
- xxxiii) M&S and the Test and Evaluation Master Plan (TEMP); T4.1; [1] [3]
- xxxiv) M&S and the System Evaluation Plan (SEP); T4.2; [3]
- xxxv) The Test/Simulation Execution Strategy (T/SES); T4.2; [3]
- xxxvi) Programmatic for M&S in T&E; T4.3; [3]
- xxxvii) M&S in test planning, test execution, and systems analysis; T4.4 T4.5 T4.6; [1] [3]
- xxxviii) M&S life-cycle costs in T&E; T4.7; [3]
- xxxix) Module case study (course notes)
- xl) Module case study continued (course notes)
- xli) Key facilities which support DoD M&S T&E (including Major Shared Resource Centers).
- xlii) Missions of the key facilities which support DoD M&S T&E.
- xliii) Principle DoD customers to the key facilities which support DoD M&S T&E.
- xliv) Current capabilities (strengths and weaknesses) of the key facilities which support DoD M&S T&E.
- xlv) Improvement and modernization activities of the key facilities which support DoD M&S T&E.
- xlvi) Emerging facilities (currently under development) which will support DoD M&S T&E.
- xlvii) Module exam (course notes)
- xlviii) Course review and feedback

## **Course Twelve**

**Introduction to Engineering M&S Applications, Parts One and Two** – This two part series of courses will be modeled after the ISE 5X3 Introduction to Engineering Modeling and Simulation Applications and ISE 5X4 Introduction to Engineering Modeling and Simulation Applications for Engineers course syllabi developed to satisfy ESRs E1 through E14 by the University of Alabama at Huntsville. These courses will each be offered both as a full academic course and as 3-6 hour web-based courses for General Awareness.

- 1) Course Name: ISE 5X3 Introduction to Engineering Modeling and Simulation Applications
- 2) Course coordinator / point of contact and contact information:  
Dr. Jeff Little, UAH CMSA, 256-824-2351, [jeffery.little@uah.edu](mailto:jeffery.little@uah.edu)  
Dr. Mikel D. Petty, UAH CMSA, 256-824-4368, [pettym@uah.edu](mailto:pettym@uah.edu)
- 3) Course description: This course will introduce a wide array of engineering modeling and simulation tools to give acquisition professionals a general understanding of key capabilities available to support design processes. The course is focused toward the non-technical professional, one who does not have an engineering or science degree, and therefore does not have a strong understanding of the principles behind the tools. Upon completion, students should gain a general awareness of the wide range of M&S support available for DoD system designs.
- 4) Modules incorporated into Course: E-1 through E-14 General Awareness modules
- 5) ESRs that the course supports and the corresponding level of mastery.
  - a) ESR E-1 General Awareness
  - b) ESR E-2 General Awareness
  - c) ESR E-3 General Awareness
  - d) ESR E-4 General Awareness
  - e) ESR E-5 General Awareness
  - f) ESR E-6 General Awareness
  - g) ESR E-7 General Awareness
  - h) ESR E-8 General Awareness
  - i) ESR E-9 General Awareness
  - j) ESR E-10 General Awareness
  - k) ESR E-12 General Awareness
  - l) ESR E-13 General Awareness
  - m) ESR E-14 General Awareness
- 6) Prerequisites assumed, and corresponding level of mastery. None.



- 7) Course maturity: Not previously taught
- 8) Number of contact hours and pace contemplated: 3 hours lecture/week for 16 weeks.
- 9) Proposed Delivery modality: Resident (face-to-face)
- 10) Proposed references and texts: See references within each engineering module.
- 11) Course learning objectives:
  - a) Describe basic structural mechanics M&S methods
  - b) Describe basic computational fluid dynamics (CFD) M&S methods
  - c) Describe basic dynamics and controls M&S methods
  - d) Describe basic thermodynamics and heat transfer M&S methods
  - e) Describe basic materials and fabrication M&S methods
  - f) Describe basic acoustic and electromagnetics M&S methods
  - g) Describe military platform systems engineering M&S methods
  - h) Describe the basic computer architectures supporting engineering M&S methods
  - i) Describe basic circuits and power systems M&S methods
  - j) Describe basic information transfer M&S methods
  - k) Describe the principles of networks applied to military applications
  - l) Describe basic terrestrial science M&S methods
  - m) Describe basic human systems integration in engineering design and supporting M&S applications
  - n) Describe basic principles of aerodynamics with applications to M&S
- 12) Course Assessment Plan
  1. Mid-term and final exams
  2. Short-answer homework assignments, ~1 per week
  3. Term Paper
- 13) Topic list by hour of instruction and reference.
  - i) Overview and Introduction to M&S (syllabus and course notes)
  - ii) Introduction to Engineering Design
  - iii) M&S and Engineering Design integration
  - iv) Introduction to computer architectures supporting M&S
  - v) DoD specific computer architectures and networks supporting M&S
  - vi) Introduction to networks applied to military applications
  - vii) DoD networks in engineering design
  - viii) Introduction to structural mechanics
  - ix) Basic structural mechanics M&S methods
  - x) Overview of current structural mechanics M&S tools
  - xi) Introduction to CFD
  - xii) Basic CFD M&S methods
  - xiii) Overview of current CFD M&S tools
  - xiv) Introduction to dynamics and controls
  - xv) Basic dynamics and controls M&S methods

- xvi) Overview of current dynamics and controls M&S tools
- xvii) Introduction to thermodynamics and heat transfer
- xviii) Basic thermodynamics and heat transfer M&S methods
- xix) Overview of current thermodynamics and heat transfer M&S tools
- xx) Introduction to materials and fabrication
- xxi) Basic materials and fabrication M&S methods
- xxii) Overview of current materials and fabrication M&S tools
- xxiii) Introduction to acoustic and electromagnetics
- xxiv) Basic acoustic and electromagnetics M&S methods
- xxv) Overview of current acoustic and electromagnetics M&S tools
- xxvi) Introduction to military platform systems engineering
- xxvii) Basic military platform systems engineering M&S methods
- xxviii) Overview of current military platform systems engineering M&S tools
- xxix) Introduction to circuits and power systems
- xxx) Basic circuits and power systems M&S methods
- xxxi) Overview of current circuits and power systems M&S tools
- xxxii) Introduction to terrestrial science
- xxxiii) Basic terrestrial science M&S methods
- xxxiv) Overview of current terrestrial science M&S tools
- xxxv) Introduction to aerodynamics & Forces in Flight (Understanding Flight by Anderson & Eberhardt, Introduction to Flight, 5<sup>th</sup> Edition, by J.D. Anderson—Chapter 2)
- xxxvi) Controls Theory (Stability and Control of Aircraft Systems, by Roy Langton—Chapters 1 & 2)
- xxxvii) Flight Control (Introduction to Flight, 5<sup>th</sup> Edition, by J.D. Anderson—Chapter 7, Sections 1, 2 & 20)
- xxxviii) Use of M&S in Flight Control Development (Aerodynamics for Engineers, 4<sup>th</sup> Edition, by J.J. Bertin & M.L. Smith—Chapter 14)
- xxxix) Introduction to Human Systems Integration (HSI)
  - (1) What is Human Systems Integration? (<http://www.nps.edu/or/hsi/>)
  - (2) Review the different types of HSI (Human Factors Engineering, System Safety, Health Hazards, Personnel Survivability, Manpower, Personnel, Training, Habitability) (Defense Acquisition Guidebook, Chapter 6)
- xl) HSI requirements outlined in DODI 5000.2 and using M&S to meet those requirements (DODI 500.2)
- xli) Use of HSI modeling in system performance and system life cycle costs (Defense Acquisition Guidebook Chapter 6.4.5) (Defense Acquisition Guidebook Chapter 6.4.5)
- xlii) Use of HSI modeling on system user population (Malonet, T.B., Baker, C.C., Kirkpatrick M., Anderson, D.E., Bost J.R., Williams, C.D., Walker S.A., & Hu, T.H.G. (1998) Payoffs and challenges of human systems integration (HSI) modeling and simulations in a virtual environment. *Naval Engineers Journal*, (110, 4), p 21-37.)
- xliii) Overview of existing M&S tools that support HSI M&S (this will need to be a dynamic compilation of existing and emerging industry standard software

which supports HIS M&S—for example, *Delmia* is currently popular within the automotive industry and is being considered for use by NASA)

- xliv) Overview of current CFD M&S tools
- xliv) Module exam (course notes)
- xlvi) Course review and feedback

## 2.4.2 All Course Syllabi (by Academic Partner)

### University of Alabama, Huntsville

- 1) Course name: ISE 5X1 Introduction to Modeling and Simulation for T&E
- 2) Course coordinator / point of contact and contact information  
 Dr. Jeffrey S. Strickland, UAH CMSA, 256-824-4415, [jeffrey.strickland@uah.edu](mailto:jeffrey.strickland@uah.edu)  
 Dr. Mikel D. Petty, UAH CMSA, 256-824-4368, [pettym@uah](mailto:pettym@uah).
- 3) Course description This course will address the use of modeling and simulation as a complement to physical testing in support of systems evaluation. The general relationships among simulation, test, and evaluation will be introduced in context of systems acquisition life-cycle management. Forms of use of simulation in support of test planning, test execution, and systems analysis will be described, characterized, and illustrated with real-world examples. Issues and opportunities relevant to the integrated use of simulation and testing will be identified; and strategies to optimize the use of scarce resources in executing test and evaluation programs will be provided.
- 4) Modules incorporated into Course T1-G, T1-U, T2-G, T2-U, T3-G, T3-U, T4-G, T4-U, T5-G, and T5-U
- 5) ESRs that the course supports and the corresponding level of mastery
  - a) ESR T-1 General Awareness and Understanding
  - b) ESR T-2 General Awareness and Understanding
  - c) ESR T-3 General Awareness and Understanding
  - d) ESR T-4 General Awareness and Understanding
  - e) ESR T-5 General Awareness and Understanding
- 6) Prerequisites assumed, and corresponding level of mastery ISE 428 - Systems Analysis and Design I; ISE 447/547 - Introduction to Systems Simulation
- 7) Course maturity Not previously taught
- 8) Number of contact hours and pace contemplated 3 hours lecture/week for 16 week.
- 9) Proposed Delivery modality: Resident (face-to-face)
- 10) Proposed references and texts
  - [1] Systems Engineering Principles and Practice, by Alexander Kossiakoff and William N. Sweet, NY: Wiley, 2003
  - [2] Department of the Army Pamphlet 73-1: Test and Evaluation in Support of Systems Acquisition, Headquarters, Department of the Army, Washington, DC, 30 May 2003.

## 11) Course learning objectives

- a) Identify and apply DoD policies and regulations related to M&S for T&E [T1]
- b) Identify types of M&S, uses and benefits, and limitations and risks for T&E [T1, T2]
- c) Identify the uses of M&S during Developmental T&E (DT&E), Operational T&E (OT&E), and Live Fire T&E [T3]
- d) Identify the uses of M&S for testing in a joint environment [T3]
- e) Describe the process and importance of M&S Validation, Verification, & Accreditation [T2]
- f) Describe the M&S program contractual process [T4]
- g) Match existing M&S T&E facilities used within the DoD to a given program need, as appropriate [T5]

12) Course assessment plan five module exams, course average to pass is 80%.

## 13) Topic list by hour of instruction and reference

- i) Introduction and overview (course notes and syllabus)
- ii) Roles, uses, limitations and trends of models and simulations of various types; T1.1; [2]
- iii) Use of M&S in systems engineering and decision support for T&E; T1.2; [2]
- iv) Use of M&S in a system's lifecycle for all phases of test and evaluation; T1.3; [1] [2]
- v) Appropriate simulation use and model fidelity for systems validation; T1.4; [2]
- vi) Restrictions, applications, limitations, and risk of using M&S during T&E; T1.5; [2]
  - (1) Risks of using M&S in evaluating a single system component in place of testing an entire configuration.
  - (2) In conjunction with/in place of live testing
- vii) Use of M&S in test planning; T1.6; [2]
- viii) Levels of risk in testing (Risk and Its Impact on VV&A, Recommended Practices Guide); T1.7 T1.8
  - (1) the application of M&S in risk reduction
  - (2) Acceptable risk involving the use of M&S in testing
- ix) Use of M&S for risk analysis and mitigation; T1.9; [2]
- x) Module exam (course notes)
- xi) Introduction and overview (course notes and syllabus)
- xii) Types of simulation used in T&E; T2.1; [2]
- xiii) Using the Data Source Matrix (DSM) to describe T&E events and simulation events; T2.2; [2]
- xiv) Appropriate use of M&S in T&E; T2.3; [2]
- xv) Data arising from live and virtual testing; T2.4; [2]
- xvi) Use of M&S in developing test scenarios and data matrices; T2.5; [2]
- xvii) Examples of M&S integrated with T&E; T2.6 T2.7; [2]

- xviii) Model-Test-Model methodology; T2.8; [2]
- xix) Issues and opportunities relevant to the integrated use of M&S in testing T2.9; [2]
- xx) Integrating results of M&S with results from other sources of T&E; T2.10; [2]
- xxi) Module exam (course notes)
- xxii) Introduction and overview (course notes and syllabus)
- xxiii) Use of M&S in evolutionary test process; T3.1; [2] and Testing of Defense Systems in an Evolutionary Acquisition Environment).
- xxiv) Role of M&S in integration testing; T3.2; [2]
- xxv) Role of M&S in developmental testing; T3.3; [2]
- xxvi) Role of M&S in operational testing; T3.4; [2]
- xxvii) Role of M&S in unit testing; T3.5; [2]
- xxviii) Role of M&S in interoperability testing; T3.7; [2]
- xxix) Role of M&S in live fire testing; T3.6; [2]
- xxx) Interrelationships between M&S and traditional forms of T&E; T3.8; [2]  
[1]
- xxxi) Test procedures for various types of testing; T3.9; [2]
- xxxii) Module exam (course notes)
- xxxiii) Introduction and overview (course notes and syllabus)
- xxxiv) M&S and the Test and Evaluation Master Plan (TEMP); T4.1; [2]
- xxxv) M&S and the System Evaluation Plan (SEP); T4.2; [2]
- xxxvi) The Test/Simulation Execution Strategy (T/SES); T4.2; [2]
- xxxvii) Programmatic for M&S in T&E; T4.3; [2]
- xxxviii) M&S in test planning, test execution, and systems analysis; T4.4 T4.5 T4.6; [2]
- xxxix) M&S life-cycle costs in T&E; T4.7; [2]
- xl) Module exam (course notes)
- xli) Key facilities which support DoD M&S T&E (including Major Shared Resource Centers).
- xl ii) Missions of the key facilities which support DoD M&S T&E.
- xl iii) Principle DoD customers to the key facilities which support DoD M&S T&E.
- xl iv) Current capabilities (strengths and weaknesses) of the key facilities which support DoD M&S T&E.
- xl v) Improvement and modernization activities of the key facilities which support DoD M&S T&E.
- xl vi) Emerging facilities (currently under development) which will support DoD M&S T&E.
- xl vii) Module exam (course notes)
- xl viii) Course review and feedback

- 1) Course name: ISE 5X2 Advanced Modeling and Simulation for T&E
- 2) Course coordinator / point of contact and contact information:  
 Dr. Jeffrey S. Strickland, UAH CMSA, 256-824-4415, [jeffrey.strickland@uah.edu](mailto:jeffrey.strickland@uah.edu)  
 Dr. Mikel D. Petty, UAH CMSA, 256-824-4368, [pettym@uah](mailto:pettym@uah)
- 3) Course description: This course is a follow-on from ISE 5X2. The will address the application of modeling and simulation as a complement to physical testing in support of systems evaluation. The general relationships among simulation, test, and evaluation will be further investigated in context of systems acquisition life-cycle management. Forms of use of simulation in support of test planning, test execution, and systems analysis will be described, characterized, and illustrated with real-world examples. Issues and opportunities relevant to the integrated use of simulation and testing will be identified; and strategies to optimize the use of scarce resources in executing test and evaluation programs will be provided.
- 4) Modules incorporated into Course: T1-A, T1-M, T2-A, T2-M, T3-A, T3-M, T4-A, T4-M, T5-A, and T5-M
- 5) ESRs that the course supports and the corresponding level of mastery.
  - a) ESR T-1 Application and Mastery
  - b) ESR T-2 Application and Mastery
  - c) ESR T-3 Application and Mastery
  - d) ESR T-4 Application and Mastery
  - e) ESR T-5 Application and Mastery
- 6) Prerequisites assumed, and corresponding level of mastery. ISE 5X1 - Introduction to Modeling and Simulation for T&E
- 7) Course maturity: Not previously taught
- 8) Number of contact hours and pace contemplated: 3 hours lecture/week for 16 week.
- 9) Proposed Delivery modality: Resident (face-to-face)
- 10) Proposed references and texts:
  - [1] Systems Engineering Principles and Practice, by Alexander Kossiakoff and William N. Sweet, NY: Wiley, 2003
  - [2] Systems Analysis, Design, and Development, by Charles Wasson, NY: Wiley, 2006
  - [3] Department of the Army Pamphlet 73-1: Test and Evaluation in Support of Systems Acquisition, Headquarters, Department of the Army, Washington, DC, 30 May 2003.

## 11) Course learning objectives:

- a) Apply DoD policies and regulations related to M&S for T&E [T1]
- b) Describe types of M&S, uses and benefits, and limitations and risks for T&E [T1, T2]
- c) Describe the uses of M&S during Developmental T&E (DT&E), Operational T&E (OT&E), and Live Fire T&E [T3]
- d) Evaluate the uses of M&S for testing in a joint environment [T3]
- e) Describe the process and importance of M&S Validation, Verification, & Accreditation [T2]
- f) Demonstrate the M&S program contractual process [T4]  
Match existing M&S T&E facilities used within the DoD to a given program need, as appropriate [T5]

## 12) Course Assessment Plan four module case studies and a final exam, course average to pass is 80%

## 13) Topic list by hour of instruction and reference.

- 1) Introduction and overview (course notes and syllabus)
- 2) Use of M&S in a system's lifecycle for all phases of test and evaluation; T1.3; [1]
- 3) Appropriate simulation use and model fidelity for systems validation; T1.4 [3]
- 4) Restrictions, applications, limitations, and risk of using M&S during T&E; T1.5; [3]
- 5) Use of M&S in open systems testing; T1.6; [1]
- 6) Levels of risk/and risk reduction using M&S in testing (Risk and Its Impact on VV&A, Recommended Practices Guide); T1.7
- 7) Module case study (course notes)
- 8) Module case study, continued (course notes)
- 9) Introduction and overview (course notes and syllabus)
- 10) Using the Data Source Matrix (DSM) to describe T&E events and simulation events; T2.2; [3]
- 11) Appropriate use of M&S in T&E; T2.3; [3]
- 12) Data arising from live and virtual testing; T2.4; [3]
- 13) Use of M&S in developing test scenarios and data matrices; T2.5; [3]
- 14) Examples of M&S integrated with T&E; T2.6 T2.7; [3]
- 15) Model-Test-Model methodology; T2.8; [3]
- 16) Issues and opportunities relevant to the integrated use of M&S in testing; T2.9; [3]
- 17) Integrating results of M&S with results from other sources of T&E; T2.10; [3]
- 18) Module case study (course notes)
- 19) Module case study, continued (course notes)
- 20) Introduction and overview (course notes and syllabus)
- 21) Use of M&S in evolutionary test process; T3.1; [3] and Testing of Defense Systems in an Evolutionary Acquisition Environment).



- 22) Role of M&S in integration testing; T3.2; [1] [3]
- 23) Role of M&S in developmental testing; T3.3; [1] [3]
- 24) Role of M&S in operational testing; T3.4; [1] [3]
- 25) Role of M&S in unit testing; T3.5; [1] [3]
- 26) Role of M&S in interoperability testing; T3.7; [1] [3]
- 27) Role of M&S in live fire testing; T3.6; [3]
- 28) Interrelationships between M&S and traditional forms of T&E; T3.8; [3]  
[2]
- 29) Test procedures for various types of testing; T3.9; [1] [3]
- 30) Module case study (course notes)
- 31) Module case study, continued (course notes)
- 32) Introduction and overview (course notes and syllabus)
- 33) M&S and the Test and Evaluation Master Plan (TEMP); T4.1; [1] [3]
- 34) M&S and the System Evaluation Plan (SEP); T4.2; [3]
- 35) The Test/Simulation Execution Strategy (T/SES); T4.2; [3]
- 36) Programmatic for M&S in T&E; T4.3; [3]
- 37) M&S in test planning, test execution, and systems analysis; T4.4 T4.5  
T4.6; [1] [3]
- 38) M&S life-cycle costs in T&E; T4.7; [3]
- 39) Module case study (course notes)
- 40) Module case study continued (course notes)
- 41) Key facilities which support DoD M&S T&E (including Major Shared  
Resource Centers).
- 42) Missions of the key facilities which support DoD M&S T&E.
- 43) Principle DoD customers to the key facilities which support DoD M&S  
T&E.
- 44) Current capabilities (strengths and weaknesses) of the key facilities which  
support DoD M&S T&E.
- 45) Improvement and modernization activities of the key facilities which  
support DoD M&S T&E.
- 46) Emerging facilities (currently under development) which will support  
DoD M&S T&E.
- 47) Module exam (course notes)
- 48) Course review and feedback

- 1) Course name: ISE 5X3 Introduction to Engineering Modeling and Simulation Applications
- 2) Course coordinator / point of contact and contact information:  
Dr. Jeff Little, UAH CMSA, 256-824-2351, [jeffery.little@uah.edu](mailto:jeffery.little@uah.edu)  
Dr. Mikel D. Petty, UAH CMSA, 256-824-4368, [pettym@uah.edu](mailto:pettym@uah.edu)
- 3) Course description: This course will introduce a wide array of engineering modeling and simulation tools to give acquisition professionals a general understanding of key capabilities available to support design processes. The course is focused toward the non-technical professional, one who does not have an engineering or science degree, and therefore does not have a strong understanding of the principles behind the tools. Upon completion, students should gain a general awareness of the wide range of M&S support available for DoD system designs.
- 4) Modules incorporated into Course: E-1 through E-14 General Awareness modules
- 5) ESRs that the course supports and the corresponding level of mastery.
  - a) ESR E-1 General Awareness
  - b) ESR E-2 General Awareness
  - c) ESR E-3 General Awareness
  - d) ESR E-4 General Awareness
  - e) ESR E-5 General Awareness
  - f) ESR E-6 General Awareness
  - g) ESR E-7 General Awareness
  - h) ESR E-8 General Awareness
  - i) ESR E-9 General Awareness
  - j) ESR E-10 General Awareness
  - k) ESR E-12 General Awareness
  - l) ESR E-13 General Awareness
  - m) ESR E-14 General Awareness
- 6) Prerequisites assumed, and corresponding level of mastery. None.
- 7) Course maturity: Not previously taught
- 8) Number of contact hours and pace contemplated: 3 hours lecture/week for 16 weeks.
- 9) Proposed Delivery modality: Resident (face-to-face)
- 10) Proposed references and texts: See references within each engineering module.
- 11) Course learning objectives:
  - a) Describe basic structural mechanics M&S methods
  - b) Describe basic computational fluid dynamics (CFD) M&S methods

- c) Describe basic dynamics and controls M&S methods
- d) Describe basic thermodynamics and heat transfer M&S methods
- e) Describe basic materials and fabrication M&S methods
- f) Describe basic acoustic and electromagnetics M&S methods
- g) Describe military platform systems engineering M&S methods
- h) Describe the basic computer architectures supporting engineering M&S methods
- i) Describe basic circuits and power systems M&S methods
- j) Describe basic information transfer M&S methods
- k) Describe the principles of networks applied to military applications
- l) Describe basic terrestrial science M&S methods
- m) Describe basic human systems integration in engineering design and supporting M&S applications
- n) Describe basic principles of aerodynamics with applications to M&S

## 12) Course Assessment Plan

- 1. Mid-term and final exams
- 2. Short-answer homework assignments, ~1 per week
- 3. Term Paper

## 13) Topic list by hour of instruction and reference.

- 1) Overview and Introduction to M&S (syllabus and course notes)
- 2) Introduction to Engineering Design
- 3) M&S and Engineering Design integration
- 4) Introduction to computer architectures supporting M&S
- 5) DoD specific computer architectures and networks supporting M&S
- 6) Introduction to networks applied to military applications
- 7) DoD networks in engineering design
- 8) Introduction to structural mechanics
- 9) Basic structural mechanics M&S methods
- 10) Overview of current structural mechanics M&S tools
- 11) Introduction to CFD
- 12) Basic CFD M&S methods
- 13) Overview of current CFD M&S tools
- 14) Introduction to dynamics and controls
- 15) Basic dynamics and controls M&S methods
- 16) Overview of current dynamics and controls M&S tools
- 17) Introduction to thermodynamics and heat transfer
- 18) Basic thermodynamics and heat transfer M&S methods
- 19) Overview of current thermodynamics and heat transfer M&S tools
- 20) Introduction to materials and fabrication
- 21) Basic materials and fabrication M&S methods
- 22) Overview of current materials and fabrication M&S tools
- 23) Introduction to acoustic and electromagnetics
- 24) Basic acoustic and electromagnetics M&S methods
- 25) Overview of current acoustic and electromagnetics M&S tools
- 26) Introduction to military platform systems engineering

- 27) Basic military platform systems engineering M&S methods
- 28) Overview of current military platform systems engineering M&S tools
- 29) Introduction to circuits and power systems
- 30) Basic circuits and power systems M&S methods
- 31) Overview of current circuits and power systems M&S tools
- 32) Introduction to terrestrial science
- 33) Basic terrestrial science M&S methods
- 34) Overview of current terrestrial science M&S tools
- 35) Introduction to aerodynamics & Forces in Flight (Understanding Flight by Anderson & Eberhardt, Introduction to Flight, 5<sup>th</sup> Edition, by J.D. Anderson—Chapter 2)
- 36) Controls Theory (Stability and Control of Aircraft Systems, by Roy Langton—Chapters 1 & 2)
- 37) Flight Control (Introduction to Flight, 5<sup>th</sup> Edition, by J.D. Anderson—Chapter 7, Sections 1, 2 & 20)
- 38) Use of M&S in Flight Control Development (Aerodynamics for Engineers, 4<sup>th</sup> Edition, by J.J. Bertin & M.L. Smith—Chapter 14)
- 39) Introduction to Human Systems Integration (HSI)
  - a) What is Human Systems Integration? (<http://www.nps.edu/or/hsi/>)
  - b) Review the different types of HSI (Human Factors Engineering, System Safety, Health Hazards, Personnel Survivability, Manpower, Personnel, Training, Habitability) (Defense Acquisition Guidebook, Chapter 6)
- 40) HSI requirements outlined in DODI 5000.2 and using M&S to meet those requirements (DODI 500.2)
- 41) Use of HSI modeling in system performance and system life cycle costs (Defense Acquisition Guidebook Chapter 6.4.5) (Defense Acquisition Guidebook Chapter 6.4.5)
- 42) Use of HSI modeling on system user population (Malonet, T.B., Baker, C.C., Kirkpatrick M., Anderson, D.E., Bost J.R., Williams, C.D., Walker S.A., & Hu, T.H.G. (1998) Payoffs and challenges of human systems integration (HSI) modeling and simulations in a virtual environment. *Naval Engineers Journal*, (110, 4), p 21-37.)
- 43) Overview of existing M&S tools that support HSI M&S (this will need to be a dynamic compilation of existing and emerging industry standard software which supports HIS M&S—for example, *Delmia* is currently popular within the automotive industry and is being considered for use by NASA)
- 44) Overview of current CFD M&S tools
- 45) Module exam (course notes)
- 46) Course review and feedback

- 1) Course name: ISE 5X4 Introduction to Engineering Modeling and Simulation Applications for Engineers
- 2) Course coordinator / point of contact and contact information:  
Dr. Jeff Little, UAH CMSA, 256-824-2351, [jeffery.little@uah.edu](mailto:jeffery.little@uah.edu)  
Dr. Mikel D. Petty, UAH CMSA, 256-824-4368, [pettym@uah.edu](mailto:pettym@uah.edu)
- 3) Course description: This course will introduce a wide array of engineering modeling and simulation tools to give acquisition professionals a general understanding of key capabilities available to support design processes. The course is focused toward the engineering or technical professional, one who has an engineering or science degree, and therefore has some understanding of the principles behind the tools. Upon completion, students should gain an understanding and appreciation of the applications of the wide range of M&S support available for DoD system designs.
- 4) Modules incorporated into Course: E-1 through E-14 Application modules
- 5) ESRs that the course supports and the corresponding level of mastery.
  - a) ESR E-1 Understanding and Application
  - b) ESR E-2 Understanding and Application
  - c) ESR E-3 Understanding and Application
  - d) ESR E-4 Understanding and Application
  - e) ESR E-5 Understanding and Application
  - f) ESR E-6 Understanding and Application
  - g) ESR E-7 Understanding and Application
  - h) ESR E-8 Understanding and Application
  - i) ESR E-9 Understanding and Application
  - j) ESR E-10 Understanding and Application
  - k) ESR E-12 Understanding and Application
  - l) ESR E-13 Understanding and Application
  - m) ESR E-14 Understanding and Application
- 6) Prerequisites assumed, and corresponding level of mastery. None.
- 7) Course maturity: Not previously taught
- 8) Number of contact hours and pace contemplated: 3 hours lecture/week for 16 weeks.
- 9) Proposed Delivery modality: Resident (face-to-face)
- 10) Proposed references and texts: See references within each engineering module.
- 11) Course learning objectives:
  - a) Describe basic structural mechanics M&S methods
  - b) Describe basic computational fluid dynamics (CFD) M&S methods

- c) Describe basic dynamics and controls M&S methods
- d) Describe basic thermodynamics and heat transfer M&S methods
- e) Describe basic materials and fabrication M&S methods
- f) Describe basic acoustic and electromagnetics M&S methods
- g) Describe military platform systems engineering M&S methods
- h) Describe the basic computer architectures supporting engineering M&S methods
- i) Describe basic circuits and power systems M&S methods
- j) Describe basic information transfer M&S methods
- k) Describe the principles of networks applied to military applications
- l) Describe basic terrestrial science M&S methods
- m) Describe basic human systems integration in engineering design and supporting M&S applications
- n) Describe basic principles of aerodynamics with applications to M&S

12) Course Assessment Plan

- 1. Mid-term and final exams
- 2. Short-answer homework assignments, ~1 per week
- 3. Term Paper

13) Topic list by hour of instruction and reference.

- 1) Overview and Introduction to M&S (syllabus and course notes)
- 2) Introduction to Engineering Design
- 3) M&S and Engineering Design integration
- 4) Introduction to computer architectures supporting M&S
- 5) DoD specific computer architectures and networks supporting M&S
- 6) Introduction to networks applied to military applications
- 7) DoD networks in engineering design
- 8) Introduction to structural mechanics
- 9) Basic structural mechanics M&S methods
- 10) Overview of current structural mechanics M&S tools
- 11) Introduction to CFD
- 12) Basic CFD M&S methods
- 13) Overview of current CFD M&S tools
- 14) Introduction to dynamics and controls
- 15) Basic dynamics and controls M&S methods
- 16) Overview of current dynamics and controls M&S tools
- 17) Introduction to thermodynamics and heat transfer
- 18) Basic thermodynamics and heat transfer M&S methods
- 19) Overview of current thermodynamics and heat transfer M&S tools
- 20) Introduction to materials and fabrication
- 21) Basic materials and fabrication M&S methods
- 22) Overview of current materials and fabrication M&S tools
- 23) Introduction to acoustic and electromagnetics
- 24) Basic acoustic and electromagnetics M&S methods
- 25) Overview of current acoustic and electromagnetics M&S tools
- 26) Introduction to military platform systems engineering

- 27) Basic military platform systems engineering M&S methods
- 28) Overview of current military platform systems engineering M&S tools
- 29) Introduction to circuits and power systems
- 30) Basic circuits and power systems M&S methods
- 31) Overview of current circuits and power systems M&S tools
- 32) Introduction to terrestrial science
- 33) Basic terrestrial science M&S methods
- 34) Overview of current terrestrial science M&S tools
- 35) Introduction to Aerodynamics and Advanced Flight Concepts (Fundamentals of Aerodynamics, 3<sup>rd</sup> Edition, by J.D. Anderson—Chapter 1)
- 36) Controls Theory (Stability and Control of Aircraft Systems, by Roy Langton—Chapters 1 & 2)
- 37) Flight Control (Introduction to Flight, 5<sup>th</sup> Edition, by J.D. Anderson-Chapter 7)
- 38) Use of M&S in Flight Control Development (Aerodynamics for Engineers, 4<sup>th</sup> Edition, by J.J. Bertin & M.L. Smith—Chapter 14, and current journal article support)
- 39) Introduction to Human Systems Integration (HSI)
  - a) What is Human Systems Integration? (<http://www.nps.edu/or/hsi/>)
  - b) Review the different types of HSI (Human Factors Engineering, System Safety, Health Hazards, Personnel Survivability, Manpower, Personnel, Training, Habitability) (Defense Acquisition Guidebook, Chapter 6)
- 40) HSI requirements outlined in DODI 5000.2 and using M&S to meet those requirements (DODI 500.2)
- 41) Use of HSI modeling in system performance and system life cycle costs (Defense Acquisition Guidebook Chapter 6.4.5) (Defense Acquisition Guidebook Chapter 6.4.5)
- 42) Use of HSI modeling on system user population (Malonet, T.B., Baker, C.C., Kirkpatrick M., Anderson, D.E., Bost J.R., Williams, C.D., Walker S.A., & Hu, T.H.G. (1998) Payoffs and challenges of human systems integration (HSI) modeling and simulations in a virtual environment. *Naval Engineers Journal*, (110, 4), p 21-37.)
- 43) Overview of existing M&S tools that support HSI M&S (this will need to be a dynamic compilation of existing and emerging industry standard software which supports HIS M&S—for example, *Delmia* is currently popular within the automotive industry and is being considered for use by NASA)
- 44) Overview of current CFD M&S tools
- 45) Module exam (course notes)
- 46) Course review and feedback

1) Course Name ISE 5X5 M&S Environments for Acquisition

2) Course coordinator

Dr. Mikel D. Petty, 256-824-4368, pettym@uah.edu

3) Course description

Architectures and attributes of modeling and simulation environments (live, virtual, constructive) and interoperability approaches (standalone, interoperable). Focus is on their application and suitability for testing and acquisition applications.

4) Modules incorporated into course

P4-G M&S environments and interoperability (General awareness)

P4-U M&S environments and interoperability (Understanding)

P4-A M&S environments and interoperability (Application)

P4-M M&S environments and interoperability (Mastery)

5) ESRs that the course supports and the corresponding level of mastery

ESR P4 General awareness, Understanding, Application, and Mastery

6) Prerequisites assumed, and corresponding level of mastery

Basic familiarity with M&S concepts, equivalent to MSIAC M&S Staff Officers Course

7) Course maturity

Not previously taught as a course; much of the material has been taught in other courses, particularly Old Dominion University's MSIM 601 course and in Certified Modeling and Simulation Professional examination preparation courses.

8) Number of contact hours and pace contemplated

Semester course: 3 lecture hours per week for 16 weeks

9) Proposed delivery modality

Face-to-face lecture, synchronous distance learning (live audio/video connection), asynchronous distance learning (web or CD)

10) Proposed references and texts

[1] R. M. Fujimoto, "Distributed Simulation and the High Level Architecture", in W. B. Rouse and K. R. Boff (Editors), *Organizational Simulation*, John Wiley & Sons, Hoboken NJ, 2005, pp. 591-609.

[2] R. M. Fujimoto, "Parallel and Distributed Simulation", in J. Banks (Editor), *Handbook of Simulation*, John Wiley & Sons, New York 1998, pp. 429-464.

[3] M. Petty, MSIM 601 and CMSP Exam Prep lecture notes.

[4] O. Balci, "Verification, Validation, and Testing", in J. Banks (Editor), *Handbook of Simulation*, John Wiley & Sons, New York 1998, pp. 335-393.

[5] J. A. Sokolowski and C. M. Banks, *Principles of Modeling and Simulation: A*



*Multidisciplinary Approach*, Wiley, New York NY, 2008.

#### 11) Course learning objectives

Correspond to sub-ESRs for ESR P4

- a) P4.1 Define the different testing environments (live, virtual, and constructive) and compare the relative advantages and disadvantages of each environment for different product and system testing applications.
- b) P4.2 Identify the attributes of an M&S application that determine whether a live, virtual, constructive, or combination environment would be most appropriate, and the values for those attributes that indicate each type.
- c) P4.3 List significant and widely used models, standalone simulations, confederated simulations, data sets, and interoperability protocol standards applied in the different environments.
- d) P4.4 Describe approaches to testing and validating models and simulations suitable for use in each of the environments, and identify degree of accuracy typically required in that environment.
- e) P4.5 Define the differences between standalone and federated simulation and give examples of each that have been used successfully in test and acquisition applications. Identify the attributes of an M&S application that determine whether a standalone simulation or a federation of interoperable simulations would be more appropriate, and the values for those attributes that indicate each type.
- f) P4.6 List current simulation interoperability protocol standards and describe the advantages and disadvantages of each in each of the different environments.
- g) P4.7 List existing resources in each of the environments, including model repositories, implemented federations of interoperable simulations, standalone simulations, standard object models, and accredited data sets, and describe the procedures for searching for resources within repositories of them.
- h) P4.8 Describe case studies of successful test and acquisition M&S applications in each of the different environments.

#### 12) Course assessment plan

1. Mid-term and final exams
2. Short-answer homework assignments, ~1 per week
3. Term paper

#### 13) Topic list by hour of instruction and reference

Listed for each hour are topic description, related sub-ESR, and reference (if any).

1. Basic concepts, definitions, and examples of live, virtual, and constructive environments; P4.1; [1] [2] [3]
2. Basic concepts, definitions, and examples of M&S application attributes; P4.2; [4]
3. Basic concepts, definitions, and examples of categories (models, standalone simulations, interoperable simulations, data sets, and interoperability protocol standards) within live, virtual, and constructive environments; P4.3; ; [1] [2] [3]
4. Basic concepts, definitions, and examples of testing and validation in live, virtual, and constructive environments; P4.4; [4]

5. Basic concepts, definitions, and examples of standalone and interoperable simulations; P4.5; ; [1] [2] [3]
6. Basic concepts, definitions, and examples of interoperability protocol standards; P4.6; [1] [2] [3]
7. Basic concepts, definitions, and examples of each type of existing resource in live, virtual, and constructive environments; P4.7; to be determined
8. Simple case studies of successful test and acquisition M&S applications; P4.8; to be determined
9. Typical product and system testing applications and advantages and disadvantages of live, virtual, and constructive environments for each; P4.1; [3]
10. Typical live, virtual, and constructive environment architectures; P4.1; [3]
11. Attributes of M&S applications typically found in live, virtual, and constructive environments; P4.2; [3]
12. Lists of significant and widely used items in each category and explanations for their significance live, virtual, and constructive environments; P4.3; to be determined
13. Details of different testing and validation methods used in live, virtual, and constructive environments; P4.4; [4]
14. Differences and advantages/disadvantages of standalone and interoperable simulations; P4.5; [1] [2] [3] [4]
15. Examples of successful use of standalone and interoperable simulations for test and acquisition applications; P4.5; to be determined
16. Technical details of current interoperability protocol standards; P4.6; [1] [2] [3]
17. Relative capabilities and typical applications of current interoperability protocol standards in live, virtual, and constructive environments; P4.6; [1] [2] [3]
18. Lists and details of existing resources in live, virtual, and constructive environments; P4.7; to be determined
19. Resource repositories in live, virtual, and constructive environments; P4.7; to be determined
20. Advanced case studies of both successful and unsuccessful test and acquisition M&S applications; P4.8; to be determined
21. Customizing live, virtual, and constructive environments for a specific application; P4.1; [1] [2] [3]
22. Determining the attributes of given M&S applications in live, virtual, and constructive environments; P4.2; to be determined
23. M&S application attributes in unusual applications and special cases; P4.2; to be determined
24. Recognizing significant, or potentially significant, items in live, virtual, and constructive environments; P4.3; to be determined
25. Performing testing and validation using existing methods in live, virtual, and constructive environments; P4.4; [4]
26. Applying standalone and interoperable simulations in test and acquisition M&S applications; P4.5; [1] [2] [3]
27. Attributes of M&S applications that determine whether a standalone or interoperable simulation would be more appropriate, and attribute values that indicate each type; P4.5; [1] [2] [3]

28. Applying interoperability protocol standards in test and acquisition M&S applications; P4.6; [1] [2] [3]
29. Procedures for examining, acquiring, customizing, and using existing resources; P4.7; to be determined
30. Adapting methods and lessons from a case study to a new test and acquisition M&S application; P4.8; to be determined
31. Analyzing a test and acquisition M&S application for lessons learned; P4.8; to be determined
32. Selecting among live, virtual, and constructive environments for a specific application based on environment characteristics; P4.1; [1] [2] [3]
33. Designing and integrating hybrid live, virtual, and constructive environments for specialized applications; P4.1; [1] [2] [3]
34. Selecting among live, virtual, and constructive environments based on M&S application attributes; P4.2; [1] [2] [3]
35. Selecting among available widely used items for an application within live, virtual, and constructive environments; P4.3; [1] [2] [3]
36. Selecting appropriate testing and validation methods in live, virtual, and constructive environments; P4.4; [4]
37. Developing new, enhanced, or hybrid environment-specific testing and validation methods in live, virtual, and constructive environments; P4.4; to be determined
38. Selecting among standalone and interoperable simulations based on the attributes of an M&S application; P4.5; [1] [2] [3]
39. Selecting among current interoperability protocol standards for a given M&S application in live, virtual, and constructive environments; P4.6; [1] [2] [3]
40. Selecting among existing resources for use in test and acquisition M&S application in live, virtual, and constructive environments; P4.7; to be determined
41. Selecting a case study relevant to a planned test and acquisition M&S application and extracting pertinent lessons learned; P4.8; to be determine

1) Course Name ISE 5X6 M&S Reuse for Acquisition

2) Course coordinator

Dr. Mikel D. Petty, 256-824-4368, pettym@uah.edu

3) Course description

Methods and technologies that support reuse of models, simulations, and data. Levels of effort associated with M&S reuse applications. Focus is on their application and suitability for testing and acquisition applications.

4) Modules incorporated into course

P14-G Reuse of models, data, and simulations (General awareness)

P14-U Reuse of models, data, and simulations (Understanding)

P14-A Reuse of models, data, and simulations (Application)

P14-M Reuse of models, data, and simulations (Mastery)

5) ESRs that the course supports and the corresponding level of mastery

ESR P14 General awareness, Understanding, Application, and Mastery

6) Prerequisites assumed, and corresponding level of mastery

Basic familiarity with M&S concepts, equivalent to MSIAC M&S Staff Officers Course

7) Course maturity

Not previously taught as a course; much of the material has been taught in other courses, particularly Old Dominion University's MSIM 601 course and in Certified Modeling and Simulation Professional examination preparation courses.

8) Number of contact hours and pace contemplated

Semester course: 3 lecture hours per week for 16 weeks

9) Proposed delivery modality

Face-to-face lecture, synchronous distance learning (live audio/video connection), asynchronous distance learning (web or CD)

10) Proposed references and texts

[1] P. K. Davis and R. H. Anderson, *Improving the Composability of Department of Defense Models and Simulations*, RAND National Defense Research Institute, Santa Monica CA, 2003.

[2] E. W. Weisel, M. D. Petty, and R. R. Mielke, "A Survey of Engineering Approaches to Composability", *Proceedings of the Spring 2004 Simulation Interoperability Workshop*, Arlington VA, April 18-23 2004, pp. 722-731.

[3] W. Royce, "The COCOMO Cost Estimation Model", in W. Royce, *Software Project Management*, Addison-Wesley, Reading MA, 1998, pp. 265-281.

11) Course learning objectives

Correspond to sub-ESRs for ESR P14

- a) P14.1 Define the different methods by which a model or simulation can be reused.
- b) P14.2 Given a model and a proposed reuse application for it, identify suitable methods to implement the reuse.
- c) P14.3 Determine the level of effort required to reuse a model, data set, or simulation in various applications under different reuse methods. Calculate the incremental level of effort required to make a model, data set, or simulation reusable.
- d) P14.4 Classify proposed reuse applications of a model, data set, or simulation as appropriate or inappropriate based on modeling paradigm, level of resolution, and bounds of validity.
- e) P14.5 Identify the assumptions behind a model, data set, or simulation, and determine how those assumptions constrain appropriate reuse applications.
- f) P14.6 List current simulation interoperability protocol standards, interoperability frameworks and middleware libraries, and composability approaches that support reuse, and describe the advantages and disadvantages of each.
- g) P14.7 List existing resources available for reuse, including model repositories, implemented federations, standalone simulations, standard object models, and accredited data sets, and describe the procedures for searching for resources within repositories of them.
- h) P14.8 Identify measures in new simulation development that will encourage reuse or make reuse more cost effective.
- i) P14.9 Identify the levels of conceptual interoperability possible between interoperable simulations, and describe the extent of functionality and reusability associated with each level.
- j) P14.10 Describe case studies of successful reuse applications of commonly used models, data sets, and simulations, and the characteristics of those applications that made the reuse successful.
- k) P14.11 Given a case study, analyze cost vs benefit for reuse of a legacy simulation.
- l) P14.12 Given a case study, analyze the additional V&V effort necessary for reuse of a legacy simulation for a new use that may differ from past uses.

## 12) Course assessment plan

- 4. Mid-term and final exams
- 5. Short-answer homework assignments, ~1 per week
- 6. Term paper

## 13) Topic list by hour of instruction and reference

Listed for each hour are topic description, related sub-ESR, and reference (if any).

- 1. Basic concepts, definitions, and examples of reuse methods; P14.1; [1] [2]
- 2. Basic concepts, definitions, and examples of reuse applications; P14.2; [1] [2]
- 3. Basic concepts, definitions, and examples of level of effort associated with reuse; P14.3; [1] [2]
- 4. Basic concepts, definitions, and examples of reuse-determining concepts (modeling paradigm, level of resolution, bounds of validity); P14.4; [1] [2]
- 5. Basic concepts, definitions, and examples of assumptions in models, data sets, and simulations; P14.5; to be determined

6. Basic concepts, definitions, and examples of different types of reuse technologies (interoperability protocol standards, interoperability frameworks and middleware layers, composability approaches); P14.6; [1] [2]
7. Basic concepts, definitions, and examples of each type of existing reuse resource; P14.7; [1]
8. Basic concepts, definitions, and examples of reuse measures; P14.8; [1]
9. Basic concepts, definitions, and examples of levels of conceptual interoperability; P14.9; to be determined
10. Simple case studies of successful reuse in test and acquisition M&S applications; P14.10; to be determined
11. Basic concepts, definitions, and examples of reuse cost versus benefit in legacy simulations; P14.11; [1]
12. Basic concepts, definitions, and examples of verification and validation effort when reusing legacy simulations; P14.12; [1]
13. Technical details and advantages/disadvantages of different reuse methods; P14.1; [1] [2]
14. Appropriate reuse methods for each category (models, data, simulations); P14.1; [1] [2]
15. Model types and typical reuse methods by model type; P14.2; [1] [2]
16. Advantages/disadvantages of reuse methods by model type; P14.2; [1] [2]
17. Level of effort advantages/disadvantages of different reuse methods; P14.3; to be determined
18. Project and software estimation methods; P14.3; [3]
19. Technical details of reuse-determine concepts; P14.4; [1] [2]
20. Detailed examples of assumptions in models, data sets, and simulations; P14.5; to be determined
21. Technical details of how assumptions affect reuse applications; P14.5; to be determined
22. Technical details of reuse technologies and how each supports reuse; P14.6; [1] [2]
23. Advantages/disadvantages of different reuse technologies; P14.6; [1] [2]
24. Lists and details of existing reuse repositories; P14.7; to be determined
25. Technical details of how reuse measures encourage reuse; P14.8; to be determined
26. Technical details of levels of conceptual interoperability; P14.9; to be determined
27. Reusability implications of each level of conceptual interoperability; P14.9; to be determined
28. Advanced case studies of both successful and unsuccessful reuse in test and acquisition M&S applications; P14.10; to be determined
29. Advanced examples of cost versus benefit in reuse of legacy simulations; P14.11; to be determined
30. Advanced examples of verification and validation effort when reusing legacy simulations; P14.12; to be determined
31. Determining which reuse method, if any, is being used in a given M&S application; P14.1; [1] [2]
32. Applying each of the reuse methods to models, data, and simulations as appropriate; P14.2; [1] [2]
33. Estimating level of effort to reuse an existing model, data set of simulation; P14.3; [3]

34. Estimating level of effort to prepare a new model, data set, or simulation for later reuse; P14.3; [3]
35. Estimating reuse level of effort in unusual test and acquisition M&S applications or novel reuse methods; P14.3; to be determined
36. Determining if a proposed reuse application of a model, data set, or simulation is appropriate; P14.4; [1] [2]
37. Approaches for determining if a proposed reuse application of a model, data set, or simulation is appropriate in unusual test and acquisition M&S applications or novel reuse method; P14.4; to be determined
38. Determining if a reuse application of model, data set, or simulation is appropriate based on assumptions; P14.5; to be determined
39. Applying different reuse technologies with a given test and evaluation M&S application; P14.6; [1] [2]
40. Procedures for examining, acquiring, customizing, and reusing existing resources; P14.7; to be determined
41. Given a reuse measure, applying it when developing a new model, data set, or simulation; P14.8; [1] [2]
42. Determining the level of technical interoperability present in a federation of interoperable simulation and the resulting reusability of that federation; P14.9; to be determined
43. Adapting methods and lessons regarding reuse from a case study to a new test and acquisition M&S application; P14.10; to be determined
44. Analyzing a test and acquisition M&S application for lessons learned regarding reuse; P14.10; to be determined
45. Performing cost versus benefit analysis in a legacy simulation reuse case study; P14.11; to be determined
46. Performing verification and validation effort analysis when reusing a legacy simulation; P14.12; to be determined
47. Selecting among reuse methods for an existing model based on technical considerations; P14.2; [1] [2]
48. Selecting among reuse methods for an existing model based on level of effort considerations; P14.3; [1] [2] [3]
49. Selecting among methods to prepare a new model, data set, or simulation for later reuse based on level of effort considerations; P14.3; [1] [2] [3]
50. Selecting among reuse applications for a given model, data set, or simulation; P14.4; [1] [2]
51. Approaches for analyzing and changing assumptions during model, data set, or simulation development to affect future reusability; P14.5; to be determined
52. Select among reuse measures for a new model, data set, or simulation; P14.8; to be determined
53. Selecting a case study relevant to reuse in a planned test and acquisition M&S application and extracting pertinent lessons learned; P14.10; to be determined

1) Course Name ISE 5X7 M&S Data Strategies for Acquisition

2) Course coordinator

Dr. Mikel D. Petty, 256-824-4368, pettym@uah.edu

3) Course description

Categories, uses, formats, and models of data for modeling and simulation. Acquiring, converting, preparing, controlling, securing, and distributing data. Focus is on their application and suitability for testing and acquisition applications.

4) Modules incorporated into course

P15-G Data strategy (General awareness)

P15-U Data strategy (Understanding)

P15-A Data strategy (Application)

P15-M Data strategy (Mastery)

plus portions of P10 M&S in the acquisition process

5) ESRs that the course supports and the corresponding level of mastery

ESR P15 General awareness, Understanding, Application, and Mastery

6) Prerequisites assumed, and corresponding level of mastery

Basic familiarity with M&S concepts, equivalent to MSIAC M&S Staff Officers Course

7) Course maturity

Not previously taught as a course; much of the material has been taught in other courses, particularly Old Dominion University's MSIM 601 course and in Certified Modeling and Simulation Professional examination preparation courses.

8) Number of contact hours and pace contemplated

Semester course: 3 lecture hours per week for 16 weeks

9) Proposed delivery modality

Face-to-face lecture, synchronous distance learning (live audio/video connection), asynchronous distance learning (web or CD)

10) Proposed references and texts

[1] S. Adelman, L. Moss, and M. Abai, *Data Strategy*, Addison-Wesley, 2005.

[2] B. P. Zeigler and P. E. Hammonds, *Modeling and Simulation-Based Data Engineering: Introducing Pragmatics into Ontologies for Net-Centric Information Exchange*, Academic Press, 2007.

11) Course learning objectives

Correspond to sub-ESRs for ESR P14

a) P15.1 List the categories of data sets required (such as terrain databases, Ph/Pk tables, and sensor performance parameters) for typical model and simulation types.



- b) P15.2 List the data requirements for typical test and acquisition M&S applications in terms of data sets, data volume, data availability, data accuracy, data classification, data storage media, and data archival.
- c) P15.3 Identify existing data resources available for reuse, including both unauthenticated (for simulation testing) and authenticated (for actual test use) data, and describe the procedures for searching for resources within repositories of them.
- d) P15.4 Define commonly used formats for documenting data (i.e., meta-data) and describe how to use each form to assess a data set's utility for a specific application.
- e) P15.5 For each type of data used by models and simulations, define commonly used formats for structuring and encoding the data (e.g., XML for entity performance parameters or CTDB for terrain) and describe how the format supports correct and appropriate use and reuse of data sets so structured.
- f) P15.6 Define concepts of data models (e.g., HLA object models), identify commonly used data models (e.g., HLA RPR FOM), and explain how data models relate to data sets.
- g) P15.7 Specify proper security procedures for safeguarding classified data sets, both input and output, during and between simulation executions.
- h) P15.8 Prepare for distribution of output data sets produced by simulation executions, including documenting data format, assumptions, accuracy, and applicability.
- i) P15.9 Describe approaches, identify tools, and estimate resources required for converting data sets from one format to another (e.g., converting terrain data from DTED to CTDB) if needed for a particular M&S application.
- j) P15.10 Estimate the effort required to acquire and create the data needed for a test or acquisition M&S application, based on data required for the simulation, existing data resources available, and data creation experiences.
- k) P15.11 Describe case studies of successful data acquisition and creation for data-intensive applications of commonly used models, data sets, and simulations, and the characteristics of those applications that made the reuse successful.

12) Course assessment plan

- 7. Mid-term and final exams
- 8. Short-answer homework assignments, ~1 per week
- 9. Term paper

13) Topic list by hour of instruction and reference

Listed for each hour are topic description, related sub-ESR, and reference (if any).

- 1. Identify the phases of the acquisition life cycle; P10.1; to be determined
- 2. Identify the principal M&S applications used in each of the phases of the acquisition life cycle; P10.2; to be determined
- 3. Describe representative examples of M&S used for each type of application in each phase of the acquisition life cycle; P10.3; to be determined
- 4. List the inputs, outputs, capabilities, and limitations of each example M&S; P10.4; to be determined
- 5. Basic concepts, definitions, and examples of data set categories (e.g., terrain databases, Ph/Pk tables, and sensor performance parameters) required for typical model and simulation types; P15.1; to be determined

6. Basic concepts, definitions, and examples of data requirements for typical test and acquisition M&S applications; P15.2; to be determined
7. Basic concepts, definitions, and examples of each type of existing data resource; P15.3; to be determined
8. Basic concepts, definitions, and examples of data documentation formats; P15.4; [1] [2]
9. Basic concepts, definitions, and examples of data encoding formats; P15.5; [1] [2]
10. Basic concepts, definitions, and examples of data models; P15.6; [1] [2]
11. Basic concepts, definitions, and examples of data security procedures; P15.7; [1] [2]
12. Basic concepts, definitions, and examples of simulation data distribution; P15.8; [2]
13. Basic concepts, definitions, and examples of data conversion; P15.9; [1] [2]
14. Basic concepts, definitions, and examples of data acquisition and creation effort; P15.10; to be determined
15. Simple case studies of successful data acquisition and creation in test and acquisition M&S applications; P15.11; to be determined
16. Technical details of simulation data sets, including representation, resolution, fidelity, and size, for typical model and simulation types; P15.1; [2]
17. Technical details and normal value ranges of data requirement parameters (e.g., data sets, data volume, data availability, data accuracy, data classification, data storage media, data archival; P15.2; .[2]
18. Lists and details of existing data repositories; P15.3; to be determined
19. Technical details and advanced examples of data documentation formats; P15.4; [1] [2]
20. Technical details and advanced examples of data encoding formats; P15.5; [1] [2]
21. Technical details and advanced examples of data models; P15.6; [1] [2]
22. Relationship of data models to data sets; P15.6; [1] [2]
23. Data security requirements and procedures; P15.7; to be determined
24. Advanced examples of data security in test and acquisition M&S applications; P15.7; to be determined
25. Advanced examples of data distribution in test and acquisition M&S applications; P15.8; to be determined
26. Advanced examples of data conversion for test and acquisition M&S applications; P15.9; to be determined
27. Available data conversion tools and utilities; P15.9; to be determined
28. Advanced examples of data acquisition and creation effort in test and acquisition M&S applications; P15.10; to be determined
29. Advanced case studies of both successful and unsuccessful data acquisition and creation in test and acquisition M&S applications; P15.11; to be determined
30. Determining data set categories for typical model and simulation types; P15.1; [2]
31. Determining data requirements for typical test and acquisition M&S applications; P15.2; [2]
32. Procedures for examining, acquiring, customizing, and reusing existing data resources; P15.3; to be determined
33. Using data documentation in each format to evaluate data utility; P15.4; [1] [2]
34. Using data encoding formats to encode or decode simulation data; P15.5; [1] [2]

35. Using data models to structure and organize data within a test and acquisition M&S application; P15.6; [1] [2]
36. Instituting and executing data security in test and acquisition M&S applications; P15.7; to be determined
37. Performing data distribution in test and acquisition M&S applications; P15.8; to be determined
38. Performing data conversion for test and acquisition M&S applications; P15.9; to be determined
39. Effects of data conversion on data resolution and accuracy; P15.9; to be determined
40. Estimating effort required for data acquisition and creation in test and acquisition M&S applications; P15.10; to be determined
41. Adapting methods and lessons regarding data acquisition and creation from a case study to a new test and acquisition M&S application; P15.11; to be determined
42. Analyzing a test and acquisition M&S application for lessons learned regarding data acquisition and creation; P15.11; to be determined
43. Selecting among data acquisition and creation alternatives; P15.10; [1] [2]
44. Selecting a case study relevant to data acquisition and creation in a planned test and acquisition M&S application and extracting pertinent lessons learned; P15.11; to be determined

## University of Central Florida

*Course Name:* Awareness of Commercial Simulation-Based Acquisition Metaphors

### *Course Coordinator*

Michael D. Proctor, Ph.D., LTC (Retired)

Associate Professor, CMSP

IEMS & IDS M&S

University of Central Florida

Engineering Building 2, Room 301-D

Tel: 407-823-5296

Fax: 407-823-3413

[mproctor@mail.ucf.edu](mailto:mproctor@mail.ucf.edu)

<http://people.cecs.ucf.edu/proctor>

### *Course Description*

This course will provide a *general awareness* of non-DoD concepts of Simulation-Based Acquisition (SBA) across the entire program life cycle of commercial companies, in order to gain possible new insights into reducing the time, resources, and risks associated with the DoD acquisition process.

### *Modules incorporated into Course:*

This course is a basic entry course or a fundamental module. This course can be incorporated as a module into the Introduction, Application, and Masters level course offerings related to this same ESR.

### *ESR Supporting the Course:*

ESR A2: General Awareness for each sub ESR.

### *Pre-requisite*

1. Rank/Seniority:

Active Military: O-1 or higher

Government Civilian: GS-5 or higher

2. Pre-Course/Training:

CLE011 and CLE023 or equivalent

### *Course Maturity*

Base on UCF course EIN6528 which was first taught as a Special Topic in 2003.

### *Contact Hours / Pace of Completion*

This is a non-Resident, self paced 3 hr-online course that may take between 2 and 6 hours depending of the prior experience and skills of the students. Students must pass the End-of-Course test within 30 calendar days of the start date.

*Proposed Delivery Modality*

Online Learning course.

*Proposed Reference and Text*

- Morgan, James M. and Liker, Jeffrey K., (2006) The Toyota Product Development System
- Bonabeau, E. (2002), "Predicting the Unpredictable," Harvard Business Review, March.
- Chambers, John C., Mullick, Satinder, and Donald D. Smith. "How to Choose the Right Forecasting Technique," HBR, July – August 1971.
- Elberse, Anita. "How Markets Help Marketers," HBR, September 2005.
- Fuchs, et al. "Strategic Integration," CMR, Spring 2000
- Georgoff, David M. & Murdick, Robert G. "Manager's Guide to Forecasting," HBR, Jan-Feb 1986
- Goldhar, Joel D. & Mariann Jelinek. "Plan for Economies of Scope," HBR November-December 1983.
- Hamel, Gary & Prahalad, C.K. "Strategic Intent," HBR, July – August 2005.
- Harvard Management Update, "Should You Be Using Simulations?" June 2000.
- Kallio, et al. "Drivers and tracers of business changes," Journal of Strategic Information Systems, 8, 1999
- Malhotra, Deepak. "Negotiate or Litigate?" Negotiation, October 2004
- Porter and Millar, "How information gives you competitive advantage," HBR, July 85. (value chain article).
- Porter, "How competitive forces shape strategy," HBR, March 1979.
- Quinn, James Brian. "Technological Forecasting," HBR, March-April 1967.
- Raynor, Michael & Jil Panetta. "A Better Way to R&D?" Strategy & Innovation, March – April, 2005.
- Ring, Peter Smith, Doz, Yves L., & Olk, Paul M. "Managing Formation Processes in R&D Consortia," CMR, Vol. 47, No. 4, Summer 2005.
- Sirkin, Harold, Keenan, Perry, & Alan Jackson. "The Hard Side of Change Management," HBR, Oct 2005
- Sobek, et al. "Another Look at How Toyota Integrates Product Development," HBR, July-August 1998.
- Spear, Steven & Bowen, H. Kent, "Decoding the DNA of the Toyota Production System," HBR, Sept – Oct 1999
- Sterman, John D., "System Dynamics Modeling: Tools for Learning in a Complex World," CMR, Vol. 43, Num. 4, Summer 2001.
- Susskind, Lawrence, "Full Engagement: Learning the Most from Negotiation Simulations," Negotiation, August 2005

- Thomke, “Simulation, learning and R&D performance,” Research Policy 27 (1998)
- Thomke, “Capturing the Real Value of Innovation Tools,” MIT Sloan Management Review, Winter 2006
- Thomke, “Enlightened Experimentation: The New Imperative for Innovation,” HBR, Feb 2001.
- Thomke, Stefan & Hippel, Eric von, “Customers as Innovators: A New Way to Create Value,” HBR April 2002.
- Ward, et al. “The Second Toyota Paradox,” Sloan Management Review, Spring 1995.

### *Course Learning Objectives*

Students who have successfully completed this course will be able to:

1. Identify commercial acquisition strategies (ESR A2.1)
2. Identify M&S benefits to commercial aircraft industry (ESR A2.2)
3. Identify M&S benefits to commercial automotive industry (ESR A2.3)
4. Identify M&S benefits to commercial Pharmaceutical industry (ESR A2.4)
5. Identify change management issues associated with M&S adoption (ESR A2.5)
6. Identify emerging CASE tool technologies and their contribution to corporate integration (ESR A2.6)

### *Course Assessment Plan*

Sectional Reviews- sets of multiple choice questions specific to each topic at the end of each course section

End-of-Course Test- general multiple choice questions on all topics taught

### *Hour-by-hour Instruction*

Hour 1: ESR A2.1& A2.2: Overview of commercial acquisition strategies and terminology and Introduction to M&S benefits to commercial aircraft.

Hour 2: ESR A2.3 & A2.4: Introduction to M&S benefits to automotive, and Pharmaceutical industries, Selected Highlights from all references above.

Hour 3: ESR A2.5 & A2.6: Change management and emerging trends in M&S tool applications, Sectional Review, Conclusion, End-of-Course Test

*Course Name:* Applying Commercial Simulation-Based Acquisition Metaphors

*Course Coordinator:*

Michael D. Proctor, Ph.D., LTC (Retired)

Associate Professor, CMSP

IEMS & IDS M&S

University of Central Florida

Engineering Building 2, Room 301-D

Tel: 407-823-5296

Fax: 407-823-3413

[mproctor@mail.ucf.edu](mailto:mproctor@mail.ucf.edu)

<http://people.cecs.ucf.edu/proctor>

*Course Description:*

This course will provide an *application capability* of essential skill requirements of non-DoD concepts of Simulation-Based Acquisition (SBA) across the entire program life cycle of commercial companies, in order to gain possible new insights into reducing the time, resources, and risks associated with the DoD acquisition process.

*Modules incorporated into Course:*

This course incorporates material covered in the Awareness and Understanding courses (modules) and will reuse the Awareness level online course learning module as is if developed.

*ESR Supporting the Course*

ESR A2: Sub ESRs taught at the Application level

*Pre-requisite*

1. Rank/Seniority:

Active Military: O-1 and above

Government Civilian: GS-5 and above

2. Pre-Course/Training:

CLE011 and CLE023 or equivalent

*Course Maturity*

Base on UCF course EIN6528 which was first taught as a Special Topic in 2003.

*Contact Hours / Pace of Completion*

This is a 3-day course with 24 contact hours. The course can be completed with 8hr-instruction per day.

*Proposed Delivery Modality*

Face-to-face teaching and will reuse the Awareness level online course learning module if developed.

*Proposed Reference and Text*

- Morgan, James M. and Liker, Jeffrey K., (2006) The Toyota Product Development System
- Harvard Business School Case studies course packet currently consisting of: Boeing: 9-305-101; Boeing: 9-688-040; Millennium Pharmaceuticals, Inc 9-600-038; BMW: 9-699-044; 9-699-045; Toyota: 9-602-035; Renault-Nissan: 9-303-023; IDEO: 9-600-143

Other references:

- Bonabeau, E. (2002), "Predicting the Unpredictable," Harvard Business Review, March.
- Chambers, John C., Mullick, Satinder, and Donald D. Smith. "How to Choose the Right Forecasting Technique," HBR, July – August 1971.
- Elberse, Anita. "How Markets Help Marketers," HBR, September 2005.
- Fuchs, et al. "Strategic Integration," CMR, Spring 2000
- Georgoff, David M. & Murdick, Robert G. "Manager's Guide to Forecasting," HBR, Jan-Feb 1986
- Goldhar, Joel D. & Mariann Jelinek. "Plan for Economies of Scope," HBR November-December 1983.
- Hamel, Gary & Prahalad, C.K. "Strategic Intent," HBR, July – August 2005.
- Harvard Management Update, "Should You Be Using Simulations?" June 2000.
- Kallio, et al. "Drivers and tracers of business changes," Journal of Strategic Information Systems, 8, 1999
- Malhotra, Deepak. "Negotiate or Litigate?" Negotiation, October 2004
- Porter and Millar, "How information gives you competitive advantage," HBR, July 85. (value chain article).
- Porter, "How competitive forces shape strategy," HBR, March 1979.
- Quinn, James Brian. "Technological Forecasting," HBR, March-April 1967.
- Raynor, Michael & Jil Panetta. "A Better Way to R&D?" Strategy & Innovation, March – April, 2005.
- Ring, Peter Smith, Doz, Yves L., & Olk, Paul M. "Managing Formation Processes in R&D Consortia," CMR, Vol. 47, No. 4, Summer 2005.
- Sirkin, Harold, Keenan, Perry, & Alan Jackson. "The Hard Side of Change Management," HBR, Oct 2005
- Sobek, et al. "Another Look at How Toyota Integrates Product Development," HBR, July-August 1998.
- Spear, Steven & Bowen, H. Kent, "Decoding the DNA of the Toyota Production System," HBR, Sept – Oct 1999
- Stermann, John D., "System Dynamics Modeling: Tools for Learning in a Complex World," CMR, Vol. 43, Num. 4, Summer 2001.
- Susskind, Lawrence, "Full Engagement: Learning the Most from Negotiation Simulations," Negotiation, August 2005



- Thomke, “Simulation, learning and R&D performance,” Research Policy 27 (1998)
- Thomke, “Capturing the Real Value of Innovation Tools,” MIT Sloan Management Review, Winter 2006
- Thomke, “Enlightened Experimentation: The New Imperative for Innovation,” HBR, Feb 2001.
- Thomke, Stefan & Hippel, Eric von, “Customers as Innovators: A New Way to Create Value,” HBR April 2002.
- Ward, et al. “The Second Toyota Paradox,” Sloan Management Review, Spring 1995.

### *Course Learning Objectives*

Students who have successfully completed this course will be able to:

1. Applies commercial acquisition strategies to multiple examples (ESR A2.1)
2. Uses M&S concepts to anticipate benefits to commercial aircraft industry (ESR A2.2)
3. Uses M&S concepts to anticipate benefits to commercial automotive industry (ESR A2.3)
4. Uses M&S concepts to anticipate benefits to commercial Pharmaceutical industry (ESR A2.4)
5. Constructs possible change management approaches associated with M&S adoption (ESR A2.5)
6. Predicts possible impacts of emerging CASE tool technologies and their contribution to corporate integration (ESR A2.6)

### *Course Assessment Plan*

Verbal Feedback during Class- to periodically check on students’ understanding of topics taught

End-of-Course Evaluation- open and closed questions to test student’s proficiency on the topics taught

Hands-on Software Training and Scenario-based Testing- short scenario-based assignment similar to case studies taught to test students’ ability in M&S software usage

Hour-by-hour Instruction:

Hour 1 and 2: ESR A2.1: Overview of commercial acquisition strategies and terminology, Syllabus

Hour 3 through 8: ESR A2.2: Introduction to M&S benefits to commercial aircraft  
Commercial case history of HOW M&S has been used to advance and sustain quality and distribute production world-wide by global commercial aircraft manufacturers from the foundation of aviation with the Wright brothers to the most current aircraft.

\*Porter, HBR, March 1979

\*Fuchs, et al CMR 2000

- \*Porter and Millar, HBR, July 85.
- \*Hamel & Prahalad, HBR, 2005
- \*HBR Case 9-305-101;
- \*Quinn, HBR 1967;
- \*Chambers, et al., HBR 1971;
- \*Georgoff & Murdick, HBR 1986
- \*HBS Case 9-688-040

Hour 9 and 17: ESR A2.3: Introduction to M&S benefits to commercial automotive industries. Commercial case history of recent radical changes in HOW M&S has been used by a Global Automotive Company to radically alter their entire software infrastructure, re-train their work force, rapidly close and then surpass other Global Automotive Commercial Companies through the productivity and time to market gains made possible through M&S

- \*HBS Case 9-602-035;
- \*Morgan, James M. and Liker, Jeffrey K., (2006) The Toyota Product Development System \*Ward, et al, Sloan Management Review, Spring 1995;
- \*Sobek, Liker & Ward, HBR July-August 1998;
- \*Spear & Bowen, HBR, 1999
- \*Thomke, MIT, 2006
- \*Thomke, HBR, 2001
- \*HBS Case 9-699-044 & 045
- \*HBS Case 9-303-023
- \*Thomke, Research Policy 27 (1998) 55-74;
- \*Goldhar & Jelink, HBR, 1983

Hour 18 and 19: ESR A2.4: Introduction to M&S benefits to commercial Pharmaceutical industries,

- \*HBS 9-600-038
- \*Raynor & Panetta, S&I, 2005
- \*Stermann, CMR, 2001
- \*Ring et al, CMR, 2005

Hour 20 through 22: ESR A2.5: Commercial case history of change management issues and approaches as it relates to M&S adoption and proliferation. Change management due to M&S tool adoption (45 hour course would have a 3 hour Student report and presentation)

- \*Susskind, Negotiation, 2005
- \*Harvard Update, 2000
- \*Bonabeau, 2002
- \*Kallio, et al Journal, 1999
- \*Sirkin, et al, HBR, 2005
- \*Malhotra, Negotiation, 2004

Hour 23 and 24: ESR A2.6: Change emerging trends in CASE tool applications,  
Sectional Review, Conclusion, End-of-Course Test  
\*Contemporary articles

Course Name: Applying Computer Technology and Army Training Modeling and Simulation (M&S) Applications in Support of Acquisition

*Course Coordinator:*

Michael D. Proctor, Ph.D., LTC (Retired)

Associate Professor, CMSP

IEMS & IDS M&S

University of Central Florida

Engineering Building 2, Room 301-D

Tel: 407-823-5296

Fax: 407-823-3413

[mproctor@mail.ucf.edu](mailto:mproctor@mail.ucf.edu)

<http://people.cecs.ucf.edu/proctor>

*Course Description:*

This course will provide an *application capability* of the theoretical fundamentals of basic computer system software tools and Army Training Modeling and Simulation applications that are used in support of acquisition. Exposure to practical Army training modeling and simulation (M&S) applications as system life cycle management tools in support of Simulation-based Acquisition (SBA) will be through cases.

*Modules incorporated into Course:*

This course incorporates material covered in the Awareness and Understanding courses (modules) and will reuse the Awareness level online course learning module as is if developed.

*ESR Supporting the Course*

ESR E8. Sub ESRs taught at the application level.

*Pre-requisite*

1. Rank/Seniority:

Active Military: O-1 and above

Government Civilian: GS-5 and above

2. Pre-Course/Training:

CLE011 and CLE023 or equivalent

*Course Maturity*

New course.

*Contact Hours / Pace of Completion*

This is a 3-day course with 24 contact hours. The course can be completed with 8hr-instruction per day.

*Proposed Delivery Modality*

The course is a mixture of face-to-face teaching and will reuse the Awareness level online course learning module if the online course (module) is developed.

*Proposed Reference and Text*

- Case Study to be developed with PEO STRI on Live Training Simulation in Acquisition (OneTESS)
- Case Study to be developed with PEO STRI on Constructive Training Simulation in Acquisition (OneSAF Objective System)
- Case Study to be developed with IBM on Rational
- OUSD (AT&L) (2006). *Acquisition Modeling and Simulation Master Plan*. Department of Defense.
- Piplani Lalik, Mercer Joseph, Roop Richard (1994). *Systems Acquisition Manager's Guide for the Use of Models and Simulations*. Defense Systems Management College.
- Proctor (Editor) (1999) *Web-based Technical Reference on Simulation Interoperability*
- Proctor Michael, Posey-Macalintal Amy, Kulonda Dennis (2003). *Why the "T" in SMART: A Constructive Synergy*. Acquisition Review Quarterly Summer 2003: 285-299
- Proctor Michael, Lipinski Michael (2000). Technical Performance Measures and Distributed-Simulation Training Systems. Acquisition Review Quarterly Winter 2000: 19-32
- Sherman William, Craig Alan (2003). *Understanding Virtual Reality*. Morgan Kaufman Publishers.
- Woodridge Michael (2002). *Multiagent Systems*. John Wiley & Sons.

*Course Learning Objectives*

Students who have successfully completed this course will be able to:

1. E8.1 Relates basic computer system architecture, operating systems, networking, introductory engineering software and their application to Modeling and Simulation (M&S) applications, introductory structured programming languages such as Fortran and C, and the use of such languages for software development
2. E8.2 Applies the use of selected Runtime software systems to build M&S scenarios to support PMs, SEs, and T&E requirements across the acquisition life cycle.
3. E8.3 Applies the use of selected Intelligent Agent software systems to build M&S scenarios to support PMs, SEs, and T&E requirements across the acquisition life cycle.
4. E8.4 Applies M&S, interoperability, and intelligent agent software tools to build massively online systems (to include gaming systems) so as to support PMs, SEs, and T&E requirements across the acquisition life cycle.
5. E8.5 Predicts alternative Live training M&S systems in support of training and T&E requirements across the acquisition life cycle.
6. E8.6 Predicts alternative virtual training M&S systems in support PMs, SEs, and T&E requirements across the acquisition life cycle.

7. E8.7 Applies Computer Assisted System Engineering tools to support project life cycle development/engineering.

*Course Assessment Plan*

Verbal Feedback during Class- to periodically check on students' understanding of topics taught

End-of-Course Evaluation- open and closed questions to test student's proficiency on the topics taught

Hands-on Software Training and Scenario-based Testing- short scenario-based assignment similar to case studies taught to test students' ability in M&S software usage

Hour-by-hour Instruction

Hour 1: Relates basic computer systems, M&S tools for acquisition (E8.1)

Hour 2: Applies Modeling Software Authoring for acquisition (E8.2)

Hour 3: Applies Runtime Software for acquisition (Presagis Vega and AIS SVS) (E8.2)

Hour 4: Applies Intelligent Agent Software for acquisition (OneSAF, Mak VR Forces, SimBionic) (E8.3)

Hour 5: Applies M&S Software with Authoring Tools (E8.2 & E8.3)

Hour 6: Applies M&S Software with Authoring Tools (E8.2 & E8.3)

Hour 7: Predicts Lab-based Acquisition Evaluation- Experimental Design with Authoring Tools (E8.2 & E8.3)

Hour 8: Predicts Lab-based Acquisition Evaluation- Experimental Design with Authoring Tools (E8.2 & E8.3)

Above 8 hours supported by:

Case Study to be developed with PEO STRI on Constructive Training Simulation in Acquisition (OneSAF Objective System)

Piplani Lalik, Mercer Joseph, Roop Richard (1994). *Systems Acquisition Manager's Guide for the Use of Models and Simulations*. Defense Systems Management College.

OUUSD (AT&L) (2006). *Acquisition Modeling and Simulation Master Plan*. Department of Defense.

Proctor (Editor) (1999) *Web-based Technical Reference on Simulation Interoperability*

Sherman William, Craig Alan (2003). *Understanding Virtual Reality*. Morgan Kaufman Publishers.

Woodridge Michael (2002). *Multiagent Systems*. John Wiley & Sons.

Hour 9: Applies massively online M&S Systems to include games for acquisition (E8.4)

Hour 10: Applies massively scenario with Online system (E8.4)

Hour 11: Applies massively scenario with Online system (E8.4)

Hour 12: Applies massively scenario with Online system (E8.4)

Hour 13: Predicts Lab-based Acquisition Evaluation- Experimental Design with Online Systems (E8.4)

Hour 14: Predicts Lab-based Acquisition Evaluation- Experimental Design with Online Systems (E8.4) (45 hour course would have one additional hour)

Above 6 hours supported by:

Proctor (Editor) (1999) Web-based Technical Reference on Simulation Interoperability

Sherman William, Craig Alan (2003). *Understanding Virtual Reality*.

Morgan Kaufman Publishers.

Woodridge Michael (2002). *Multiagent Systems*. John Wiley & Sons.

Hour 15: Diagram SMART Snake Chart Structure and Concept for Live Training M&S for acquisition (E8.5)

Hour 16: Relate Live Training M&S for Acquisition (OneTESS) (E8.5)

Hour 17: Predict Live Training M&S Case Study (OneTESS) (E8.5)

Above 3 hours supported by:

Case Study to be developed with PEO STRI on Live Training Simulation in Acquisition (OneTESS)

Hour 18: Diagram SMART Snake Chart Structure and Concept for Virtual Training M&S for acquisition (E8.6)

Hour 19: Relate Virtual Training M&S for Acquisition (CCTT) (E8.6)

Hour 20: Predict Virtual Training M&S Case Study (CCTT) (E8.6)

Above 3 hours supported by:

Proctor Michael, Posey-Macalintal Amy, Kulonda Dennis (2003). *Why the "T" in SMART: A Constructive Synergy*. Acquisition Review Quarterly Summer 2003: 285-299

Proctor Michael, Lipinski Michael (2000). Technical Performance Measures and Distributed-Simulation Training Systems. Acquisition Review Quarterly Winter 2000: 19-32

Hour 21: Apply Computer Assisted System Engineering software (E8.7)

Hour 22: Apply Computer Aided System Engineering Case Study (E8.7)

Hour 23: Apply Computer Aided System Engineering Case Study(E8.7)  
Case Study to be developed with IBM on Rational

Hour 24: Conclusion and End-of-Course Evaluation



*Course Name:* Awareness of Commercial Simulation-Based Acquisition Metaphors

*Course Coordinator*

Michael D. Proctor, Ph.D., LTC (Retired)

Associate Professor, CMSP

IEMS & IDS M&S

University of Central Florida

Engineering Building 2, Room 301-D

Tel: 407-823-5296

Fax: 407-823-3413

[mproctor@mail.ucf.edu](mailto:mproctor@mail.ucf.edu)

<http://people.cecs.ucf.edu/proctor>

*Course Description:*

This course will provide a *general awareness* of the essential skill requirements of basic computer system software tools and Army Training Modeling and Simulation applications that are used in support of acquisition. Exposure to practical Army training modeling and simulation (M&S) applications as system life cycle management tools in support of Simulation-based Acquisition (SBA) will be through cases.

*Modules incorporated into Course:*

This course is a basic entry course or a fundamental module. This course can be incorporated as a module into the Introduction, Application, and Masters level course offerings related to this same ESR.

*ESR Supporting the Course*

ESR E8. General Awareness for each sub ESR.

*Pre-requisite*

1. Rank/Seniority:

Active Military: O-1 and above

Government Civilian: GS-5 and above

2. Pre-Course/Training:

CLE011 and CLE023 or equivalent

*Course Maturity*

New course.

*Contact Hours / Pace of Completion*

This is a non-Resident, self paced 3 hr-online course that may take between 2 and 6 hours depending of the prior experience and skills of the students. Students must pass the End-of-Course test within 30 calendar days of the start date.

*Proposed Delivery Modality*

Online learning course.

### *Proposed Reference and Text*

- e Study to be developed with PEO STRI on Live Training Simulation in Acquisition (OneTESS)
- Case Study to be developed with PEO STRI on Constructive Training Simulation in Acquisition (OneSAF Objective System)
- Case Study to be developed with IBM on Rational
- OUSD (AT&L) (2006). *Acquisition Modeling and Simulation Master Plan*. Department of Defense.
- Piplani Lalik, Mercer Joseph, Roop Richard (1994). *Systems Acquisition Manager's Guide for the Use of Models and Simulations*. Defense Systems Management College.
- Proctor (Editor) (1999) Web-based Technical Reference on Simulation Interoperability
- Proctor Michael, Posey-Macalintal Amy, Kulonda Dennis (2003). *Why the "T" in SMART: A Constructive Synergy*. Acquisition Review Quarterly Summer 2003: 285-299
- Proctor Michael, Lipinski Michael (2000). Technical Performance Measures and Distributed-Simulation Training Systems. Acquisition Review Quarterly Winter 2000: 19-32
- Sherman William, Craig Alan (2003). *Understanding Virtual Reality*. Morgan Kaufman Publishers.
- Woodridge Michael (2002). *Multiagent Systems*. John Wiley & Sons.

### *Course Learning Objectives*

Students who have successfully completed this course will be able to:

1. E8.1 Identifies basic computer system architecture, operating systems, networking, introductory engineering software and their application to Modeling and Simulation (M&S) applications, introductory structured programming languages such as Fortran and C, and the use of such languages for software development
2. E8.2 Recalls the use of selected Modeling and Runtime software systems to build M&S scenarios to support PMs, SEs, and T&E requirements across the acquisition life cycle.
3. E8.3 Recalls the use of selected Intelligent Agent software systems to build M&S scenarios to support PMs, SEs, and T&E requirements across the acquisition life cycle.
4. E8.4 Recalls M&S, interoperability, and intelligent agent software tools to build massively online systems (to include gaming systems) so as to support PMs, SEs, and T&E requirements across the acquisition life cycle.
5. E8.5 Knows alternative Live training M&S systems in support of training and T&E requirements across the acquisition life cycle.
6. E8.6 Knows alternative virtual training M&S systems in support PMs, SEs, and T&E requirements across the acquisition life cycle.
7. E8.7 Identifies Computer Assisted System Engineering tools to support project life cycle development/engineering.

*Course Assessment Plan*

Sectional Reviews- sets of multiple choice questions specific to each topic at the end of each course section

End-of-Course Test- general multiple choice questions on all topics taught

Hour-by-hour Instruction

Hour 1: Overview of computer systems and terminology Modeling, Runtime Software, Intelligent Agent Software, Massively Online Systems. (ESR E8.1 E8.2, E8.3, E8.4)

Hour 2: Introduction to Live and Virtual Training M&S for Acquisition (ESR E8.5, E8.6)

Hour 3: Introduction to CASE tools for Acquisition, Conclusion, End-of-Course Test (ESR E8.7)

*Course Name:* Commercial Simulation-Based Acquisition Metaphors

*Course Coordinator*

Michael D. Proctor, Ph.D., LTC (Retired)

Associate Professor, CMSP

IEMS & IDS M&S

University of Central Florida

Engineering Building 2, Room 301-D

Tel: 407-823-5296

Fax: 407-823-3413

[mproctor@mail.ucf.edu](mailto:mproctor@mail.ucf.edu)

<http://people.cecs.ucf.edu/proctor>

*Course Description*

This course will provide an *educational mastery* (a masters level course that is part of a masters program in modeling and simulation) of essential skill requirements of non-DoD concepts of Simulation-Based Acquisition (SBA) across the entire program life cycle of commercial companies, in order to gain possible new insights into reducing the time, resources, and risks associated with the DoD acquisition process.

*Modules incorporated into Course:*

This course incorporates ESR A2 material covered in the Awareness, Understanding, and Application courses (modules) and will reuse the Awareness level online course learning module if developed.

*ESR Supporting the Course:*

ESR A2: Sub ESR taught at Educational Mastery (part of a masters program) competency level or at the maximum level specified in the matrix.

*Pre-requisite*

1. Rank/Seniority:

Active Military: O-3 and above

Government Civilian: GS-9 and above

2. Pre-Course/Training:

CLE011 and CLE023 or equivalent

*Course Maturity*

Base on UCF course EIN6528 which was first taught as a Special Topic in 2003.

*Contact Hours / Pace of Completion*

This is a quarter or semester-long (12 to 15 weeks) course with 36 to 45 contact hours with 3hr-instruction per week. Alternatively the course may be accomplished in a shorter period of time covering the same number of contact hours but with a faster paced setting being 6 hours per week.

*Proposed Delivery Modality*

The course is a mixture of face-to-face teaching and will reuse the Awareness level online course learning module if that online course (module) is developed.

*Proposed Reference and Text*

- Morgan, James M. and Liker, Jeffrey K., (2006) The Toyota Product Development System
- Harvard Business School Case studies course packet currently consisting of: Boeing: 9-305-101; Boeing: 9-688-040; Millennium Pharmaceuticals, Inc 9-600-038; BMW: 9-699-044; 9-699-045; Toyota: 9-602-035; Renault-Nissan: 9-303-023; IDEO: 9-600-143

*Other references:*

- Bonabeau, E. (2002), "Predicting the Unpredictable," Harvard Business Review, March.
- Chambers, John C., Mullick, Satinder, and Donald D. Smith. "How to Choose the Right Forecasting Technique," HBR, July – August 1971.
- Elberse, Anita. "How Markets Help Marketers," HBR, September 2005.
- Fuchs, et al. "Strategic Integration," CMR, Spring 2000
- Georgoff, David M. & Murdick, Robert G. "Manager's Guide to Forecasting," HBR, Jan-Feb 1986
- Goldhar, Joel D. & Mariann Jelinek. "Plan for Economies of Scope," HBR November-December 1983.
- Hamel, Gary & Prahalad, C.K. "Strategic Intent," HBR, July – August 2005.
- Harvard Management Update, "Should You Be Using Simulations?" June 2000.
- Kallio, et al. "Drivers and tracers of business changes," Journal of Strategic Information Systems, 8, 1999
- Malhotra, Deepak. "Negotiate or Litigate?" Negotiation, October 2004
- Porter and Millar, "How information gives you competitive advantage," HBR, July 85. (value chain article).
- Porter, "How competitive forces shape strategy," HBR, March 1979.
- Quinn, James Brian. "Technological Forecasting," HBR, March-April 1967.
- Raynor, Michael & Jil Panetta. "A Better Way to R&D?" Strategy & Innovation, March – April, 2005.
- Ring, Peter Smith, Doz, Yves L., & Olk, Paul M. "Managing Formation Processes in R&D Consortia," CMR, Vol. 47, No. 4, Summer 2005.
- Sirkin, Harold, Keenan, Perry, & Alan Jackson. "The Hard Side of Change Management," HBR, Oct 2005
- Sobek, et al. "Another Look at How Toyota Integrates Product Development," HBR, July-August 1998.
- Spear, Steven & Bowen, H. Kent, "Decoding the DNA of the Toyota Production System," HBR, Sept – Oct 1999
- Sterman, John D., "System Dynamics Modeling: Tools for Learning in a Complex World," CMR, Vol. 43, Num. 4, Summer 2001.
- Susskind, Lawrence, "Full Engagement: Learning the Most from Negotiation Simulations," Negotiation, August 2005

- Thomke, “Simulation, learning and R&D performance,” Research Policy 27 (1998)
- Thomke, “Capturing the Real Value of Innovation Tools,” MIT Sloan Management Review, Winter 2006
- Thomke, “Enlightened Experimentation: The New Imperative for Innovation,” HBR, Feb 2001.
- Thomke, Stefan & Hippel, Eric von, “Customers as Innovators: A New Way to Create Value,” HBR April 2002.
- Ward, et al. “The Second Toyota Paradox,” Sloan Management Review, Spring 1995.
- Christensen, Clayton M. (1997) The Innovator’s Dilemma
- Schrage, Michael (2000) Serious Play
- Thomke, Stefan (2003) Experimentation Matters

### *Course Learning Objectives*

Students who have successfully completed this course will be able to:

1. Recognize logical fallacies in the inconsistent in the use of commercial acquisition strategies (ESR A2.1)
2. Synthesize M&S concepts to anticipate benefits to commercial aircraft industry (ESR A2.2)
3. Analyze, compare and contrast applications of M&S in various commercial automotive industry (ESR A2.3)
4. Evaluate the application of M&S to the commercial Pharmaceutical industry (ESR A2.4)
5. Appraise possible change management approaches associated with M&S adoption (ESR A2.5)
6. Appraise possible impacts of emerging CASE tool technologies and their contribution to corporate integration (ESR A2.6)

### *Course Assessment Plan*

Verbal Feedback during Class- to periodically check on students’ understanding of topics taught

Term Papers- research-based projects to test students’ ability to synthesize knowledge and draw conclusions based on knowledge learnt in class

Lab-based Project- open-ended practical project to test students’ hands-on and cognitive ability to design experiments and demonstrate M&S software applications

End-of-Course Evaluation- open-ended and closed questions to test student’s tacit knowledge in subject matter

### *Hour-by-hour Instruction*

Hour 1 and 2: ESR A2.1: Overview of commercial acquisition strategies and terminology, Syllabus

Hour 3 through 8: ESR A2.2: Introduction to M&S benefits to commercial aircraft  
Commercial case history of HOW M&S has been used to advance and sustain quality and distribute production world-wide by global commercial aircraft manufacturers from the foundation of aviation with the Wright brothers to the most current aircraft.

- \*Porter, HBR, March 1979
- \*Fuchs, et al CMR 2000
- \*Porter and Millar, HBR, July 85.
- \*Hamel & Prahalad, HBR, 2005
- \*HBR Case 9-305-101;
- \*Quinn, HBR 1967;
- \*Chambers, et al., HBR 1971;
- \*Georgoff & Murdick, HBR 1986
- \*HBS Case 9-688-040

Hour 9 and 10: ESR A2.2: Student group Aviation Case History research and presentation

Hour 11 and 22: ESR A2.3: Introduction to M&S benefits to commercial automotive industries. Commercial case history of recent radical changes in HOW M&S has been used by a Global Automotive Company to radically alter their entire software infrastructure, re-train their work force, rapidly close and then surpass other Global Automotive Commercial Companies through the productivity and time to market gains made possible through M&S

- \*HBS Case 9-602-035;
- \*Morgan, James M. and Liker, Jeffrey K., (2006) The Toyota Product Development System \*Ward, et al, Sloan Management Review, Spring 1995;
- \*Sobek, Liker & Ward, HBR July-August 1998;
- \*Spear & Bowen, HBR, 1999
- \*Thomke, MIT, 2006
- \*Thomke, HBR, 2001
- \*HBS Case 9-699-044 & 045
- \*HBS Case 9-303-023
- \*Thomke, Research Policy 27 (1998) 55-74;
- \*Goldhar & Jelink, HBR, 1983

Hour 23 through 25: ESR A2.3: Individual independent research project reports and presentations on automotive industry.

Hour 26 and 28: ESR A2.4: Introduction to M&S benefits to commercial Pharmaceutical industries,

- \*HBS 9-600-038
- \*Raynor & Panetta, S&I, 2005
- \*Stermann, CMR, 2001
- \*Ring et al, CMR, 2005

Hour 29 through 32: ESR A2.5: Commercial case history of change management issues and approaches as it relates to M&S adoption and proliferation. Change management due to M&S tool adoption (45 hour course would have a 3 hour Student report and presentation)

\*Susskind, Negotiation, 2005

\*Harvard Update, 2000

\*Bonabeau, 2002

\*Kallio, et al Journal, 1999

\*Sirkin, et al, HBR, 2005

\*Malhotra, Negotiation, 2004

Hour 35 and 36: ESR A2.6: Commercial case history of the use of Computer Assisted System Engineering tools to describe the relationship within and between systems life cycles within a corporation and close gaps between those systems. Change emerging trends in CASE tool applications, Sectional Review, Conclusion, End-of-Course Test (45 hour course would have a 3 hour Student report and presentation)

\*Contemporary articles

*\*Note the above syllabus is a best estimate for time, content, and references at the time of writing and is subject to change at any time.*



Course Name: Computer Technology and Army Training Modeling and Simulation (M&S) Applications in Support of Acquisition

*Course Coordinator:*

Michael D. Proctor, Ph.D., LTC (Retired)

Associate Professor, CMSP

IEMS & IDS M&S

University of Central Florida

Engineering Building 2, Room 301-D

Tel: 407-823-5296

Fax: 407-823-3413

[mproctor@mail.ucf.edu](mailto:mproctor@mail.ucf.edu)

<http://people.cecs.ucf.edu/proctor>

*Course Description:*

This course seeks to provide an *educational mastery* (a masters level course that is part of a masters program in modeling and simulation) of essential skill requirements of basic computer system software tools and Army Training Modeling and Simulation applications that are used in support of acquisition. Exposure to practical Army training modeling and simulation (M&S) applications as system life cycle management tools in support of Simulation-based Acquisition (SBA) will be through cases.

*Modules incorporated into Course:*

This course incorporates ESR A2 material covered in the Awareness, Understanding, and Application courses (modules) and will reuse the Awareness level online course learning module if developed.

*ESR Supporting the Course*

ESR E8. Sub ESR taught at Educational Mastery (part of a masters program) competency level or at the maximum level specified in the matrix.

*Pre-requisite*

1. Rank/Seniority:

Active Military: O-3 and above

Government Civilian: GS-9 and above

2. Pre-Course/Training:

CLE011 and CLE023 or equivalent

*Course Maturity*

New course.

*Contact Hours / Pace of Completion*

This is a quarter or semester-long (12 to 15 weeks) course with 36 to 45 contact hours with 3hr-instruction per week. Alternatively the course may be accomplished in a shorter period of time covering the same number of contact hours but with a faster paced setting being 6 hours per week.

*Proposed Delivery Modality*

The course is a mixture of face-to-face teaching and will reuse the Awareness level online course learning module if the online course (module) is developed.

*Proposed Reference and Text*

- Case Study to be developed with PEO STRI on Live Training Simulation in Acquisition (OneTESS)
- Case Study to be developed with PEO STRI on Constructive Training Simulation in Acquisition (OneSAF Objective System)
- Case Study to be developed with IBM on Rational
- OUSD (AT&L) (2006). *Acquisition Modeling and Simulation Master Plan*. Department of Defense.
- Piplani Lalik, Mercer Joseph, Roop Richard (1994). *Systems Acquisition Manager's Guide for the Use of Models and Simulations*. Defense Systems Management College.
- Proctor (Editor) (1999) *Web-based Technical Reference on Simulation Interoperability*
- Proctor Michael, Posey-Macalintal Amy, Kulonda Dennis (2003). *Why the "T" in SMART: A Constructive Synergy*. Acquisition Review Quarterly Summer 2003: 285-299
- Proctor Michael, Lipinski Michael (2000). Technical Performance Measures and Distributed-Simulation Training Systems. Acquisition Review Quarterly Winter 2000: 19-32
- Sherman William, Craig Alan (2003). *Understanding Virtual Reality*. Morgan Kaufman Publishers.
- Woodridge Michael (2002). *Multiagent Systems*. John Wiley & Sons.

*Course Learning Objectives*

Students who have successfully completed this course will be able to:

1. ESR E8.1 Compare and contrast basic computer system architecture, operating systems, networking, introductory engineering software and their application to Modeling and Simulation (M&S) applications, introductory structured programming languages such as Fortran and C, and the use of such languages for software development
2. ESR E8.2 Compare and contrast the use of selected Modeling and Runtime software systems to build M&S scenarios to support PMs, SEs, and T&E requirements across the acquisition life cycle.
3. ESR E8.3 Compare and Contrast the use of selected Intelligent Agent software systems to build M&S scenarios to support PMs, SEs, and T&E requirements across the acquisition life cycle.
4. ESR E8.4 Compare and Contrast M&S, interoperability, and intelligent agent software tools to build massively online systems (to include gaming systems) so as to support PMs, SEs, and T&E requirements across the acquisition life cycle.

5. ESR E8.5 Compare and Contrast alternative Live training M&S systems in support of training and T&E requirements across the acquisition life cycle.
6. ESR E8.6 Compare and Contrast alternative virtual training M&S systems in support PMs, SEs, and T&E requirements across the acquisition life cycle.
7. ESR E8.7 Compare and Contrast Computer Assisted System Engineering tools to support project life cycle development/engineering.

#### *Course Assessment Plan*

Verbal Feedback during Class- to periodically check on students' understanding of topics taught

Term Papers- research-based projects to test students' ability to synthesize knowledge and draw conclusions based on knowledge learnt in class

Lab-based Project- open-ended practical project to test students' hands-on and cognitive ability to design experiments and demonstrate M&S software applications

End-of-Course Evaluation- open-ended and closed questions to test student's tacit knowledge in subject matter

#### Hour-by-hour Instruction

Hour 1: Compare and contrast basic computer systems, M&S tools for acquisition (E8.1)

Hour 2: Compare and contrast Modeling Software Authoring for acquisition (E8.2)

Hour 3: Compare and contrast Runtime Software for acquisition (Presagis Vega and AIS SVS) (The 45 hour course would have 3 hours on each topic) (E8.2)

Hour 4: Compare and contrast Intelligent Agent Software for acquisition (OneSAF, Mak VR Forces, SimBionic) (E8.3)

Hour 5: Compose M&S Software with Authoring Tools (E8.2 & E8.3)

Hour 6: Compose M&S Software with Authoring Tools (E8.2 & E8.3)

Hour 7: Infers Lab-based Acquisition Evaluation- Experimental Design with Authoring Tools (E8.2 & E8.3)

Hour 8: Infers Lab-based Acquisition Evaluation- Experimental Design with Authoring Tools (E8.2 & E8.3)

Above 8 hours supported by:

Case Study to be developed with PEO STRI on Constructive Training Simulation in Acquisition (OneSAF Objective System)

Piplani Lalik, Mercer Joseph, Roop Richard (1994). *Systems Acquisition Manager's Guide for the Use of Models and Simulations*. Defense Systems Management College.

OUSD (AT&L) (2006). *Acquisition Modeling and Simulation Master Plan*. Department of Defense.

Proctor (Editor) (1999) *Web-based Technical Reference on Simulation Interoperability*

Sherman William, Craig Alan (2003). *Understanding Virtual Reality*. Morgan Kaufman Publishers.

Woodridge Michael (2002). *Multiagent Systems*. John Wiley & Sons.

Hour 9: Compare and contrast massively online M&S Systems to include games for acquisition (E8.4)

Hour 10: Compose massively scenario with Online system (E8.4)

Hour 11: Compose massively scenario with Online system (E8.4)

Hour 12: Compose massively scenario with Online system (E8.4)

Hour 13: Infer Lab-based Acquisition Evaluation- Experimental Design with Online Systems (E8.4)

Hour 14: Infer Lab-based Acquisition Evaluation- Experimental Design with Online Systems (E8.4) (45 hour course would have one additional hour)

Above 6 hours supported by:

Proctor (Editor) (1999) *Web-based Technical Reference on Simulation Interoperability*

Sherman William, Craig Alan (2003). *Understanding Virtual Reality*. Morgan Kaufman Publishers.

Woodridge Michael (2002). *Multiagent Systems*. John Wiley & Sons.

Hour 15: Diagram SMART Snake Chart Structure and Concept for Live Training M&S for acquisition (E8.5)

Hour 16: Compare and Contrast Live Training M&S for Acquisition (OneTESS) (E8.5)

Hour 17: Analyze Live Training M&S Case Study (OneTESS) (E8.5)

Above 3 hours supported by:

Case Study to be developed with PEO STRI on Live Training Simulation in Acquisition (OneTESS)

Hour 18: Diagram SMART Snake Chart Structure and Concept for Virtual Training M&S for acquisition (E8.6)

Hour 19: Compare and Contrast Virtual Training M&S for Acquisition (CCTT) (E8.6)

Hour 20: Analyze Virtual Training M&S Case Study (CCTT) (E8.6)

Above 3 hours supported by:

Proctor Michael, Posey-Macalintal Amy, Kulonda Dennis (2003). *Why the "T" in SMART: A Constructive Synergy*. Acquisition Review Quarterly Summer 2003: 285-299

Proctor Michael, Lipinski Michael (2000). Technical Performance Measures and Distributed-Simulation Training Systems. Acquisition Review Quarterly Winter 2000: 19-32

Hour 21: Discuss with Guest Lecture Live, Virtual, and Constructive Training simulation use for acquisition (E8.2, E8.5 and E8.6)

Hour 22: Discuss with Guest Lecture Live, Virtual, and Constructive Training simulation use for acquisition (E8.2, E8.5 and E8.6)

Hour 23: Discuss with Guest Lecture Live, Virtual, and Constructive Training simulation use for acquisition (E8.2, E8.5 and E8.6)

Above 3 hours to be supported with

Case Study to be developed with PEO STRI on Constructive Training Simulation in Acquisition (OneSAF Objective System)

Case Study to be developed with PEO STRI on Live Training Simulation in Acquisition (OneTESS)

Proctor Michael, Posey-Macalintal Amy, Kulonda Dennis (2003). *Why the "T" in SMART: A Constructive Synergy*. Acquisition Review Quarterly Summer 2003: 285-299

Proctor Michael, Lipinski Michael (2000). Technical Performance Measures and Distributed-Simulation Training Systems. Acquisition Review Quarterly Winter 2000: 19-32

Hour 24: Compare and Contrast Computer Assisted System Engineering software (E8.7)

Hour 25: Compose Computer Aided System Engineering Case Study (E8.7)

Hour 26: Compose Computer Aided System Engineering Case Study (E8.7) (45 hour course would have 3 additional hours)

Hour 27: Infer Lab-based System Acquisition with Computer-Aided System Engineering Tools (E8.7)

Hour 28: Infer Lab-based System Acquisition with Computer-Aided System Engineering Tools (E8.7)

Hour 29: Infer Lab-based System Acquisition with Computer-Aided System Engineering Tools (E8.7)

Above 6 hours supported by  
Case Study to be developed with IBM on Rational

Hour 30 - 35: Student Term Paper Presentation and Sharing (All ESRs and references)

Hour 36: Conclusion and End-of-Course Evaluation

*\* Note the above syllabus is a best estimate for time, content, and references at the time of writing and is subject to change at any time.*

*Course Name:* Understanding Commercial Simulation-Based Acquisition Metaphors

*Course Coordinator*

Michael D. Proctor, Ph.D., LTC (Retired)

Associate Professor, CMSP

IEMS & IDS M&S

University of Central Florida

Engineering Building 2, Room 301-D

Tel: 407-823-5296

Fax: 407-823-3413

[mproctor@mail.ucf.edu](mailto:mproctor@mail.ucf.edu)

<http://people.cecs.ucf.edu/proctor>

*Course Description*

This course will provide an *understanding* of essential skill requirements of non-DoD concepts of Simulation-Based Acquisition (SBA) across the entire program life cycle of commercial companies, in order to gain possible new insights into reducing the time, resources, and risks associated with the DoD acquisition process.

*Modules incorporated into Course:*

This course incorporates ESR A2 material covered in the Awareness course (modules).

*ESR Supporting the Course*

ESR A2: Taught at understanding level of each sub ESR

*Pre-requisite*

1. Rank/Seniority:

Active Military: O-1 and above

Government Civilian: GS-5 and above

2. Pre-Course/Training:

CLE011 and CLE023 or equivalent

*Course Maturity*

Base on UCF course EIN6528 which was first taught as a Special Topic in 2003.

*Contact Hours / Pace of Completion*

This is a one-day seminar with 8 contact hours.

*Proposed Delivery Modality*

Mixture of face-to-face teaching and will reuse the Awareness level content and the corresponding online course learning module if developed.

*Proposed Reference and Text*

- Morgan, James M. and Liker, Jeffrey K., (2006) The Toyota Product Development System

- Bonabeau, E. (2002), "Predicting the Unpredictable," Harvard Business Review, March.
- Chambers, John C., Mullick, Satinder, and Donald D. Smith. "How to Choose the Right Forecasting Technique," HBR, July – August 1971.
- Elberse, Anita. "How Markets Help Marketers," HBR, September 2005.
- Fuchs, et al. "Strategic Integration," CMR, Spring 2000
- Georgoff, David M. & Murdick, Robert G. "Manager's Guide to Forecasting," HBR, Jan-Feb 1986
- Goldhar, Joel D. & Mariann Jelinek. "Plan for Economies of Scope," HBR November-December 1983.
- Hamel, Gary & Prahalad, C.K. "Strategic Intent," HBR, July – August 2005.
- Harvard Management Update, "Should You Be Using Simulations?" June 2000.
- Kallio, et al. "Drivers and tracers of business changes," Journal of Strategic Information Systems, 8, 1999
- Malhotra, Deepak. "Negotiate or Litigate?" Negotiation, October 2004
- Porter and Millar, "How information gives you competitive advantage," HBR, July 85. (value chain article).
- Porter, "How competitive forces shape strategy," HBR, March 1979.
- Quinn, James Brian. "Technological Forecasting," HBR, March-April 1967.
- Raynor, Michael & Jil Panetta. "A Better Way to R&D?" Strategy & Innovation, March – April, 2005.
- Ring, Peter Smith, Doz, Yves L., & Olk, Paul M. "Managing Formation Processes in R&D Consortia," CMR, Vol. 47, No. 4, Summer 2005.
- Sirkin, Harold, Keenan, Perry, & Alan Jackson. "The Hard Side of Change Management," HBR, Oct 2005
- Sobek, et al. "Another Look at How Toyota Integrates Product Development," HBR, July-August 1998.
- Spear, Steven & Bowen, H. Kent, "Decoding the DNA of the Toyota Production System," HBR, Sept – Oct 1999
- Sterman, John D., "System Dynamics Modeling: Tools for Learning in a Complex World," CMR, Vol. 43, Num. 4, Summer 2001.
- Susskind, Lawrence, "Full Engagement: Learning the Most from Negotiation Simulations," Negotiation, August 2005
- Thomke, "Simulation, learning and R&D performance," Research Policy 27 (1998)
- Thomke, "Capturing the Real Value of Innovation Tools," MIT Sloan Management Review, Winter 2006
- Thomke, "Enlightened Experimentation: The New Imperative for Innovation," HBR, Feb 2001.
- Thomke, Stefan & Hippel, Eric von, "Customers as Innovators: A New Way to Create Value," HBR April 2002.
- Ward, et al. "The Second Toyota Paradox," Sloan Management Review, Spring 1995.

### *Course Learning Objectives*

Students who have successfully completed this course will be able to:



1. Identify and explain differences in commercial acquisition strategies (ESR A2.1)
2. Discuss M&S benefits to commercial aircraft industry (ESR A2.2)
3. Discuss M&S benefits to commercial automotive industry (ESR A2.3)
4. Discuss M&S benefits to commercial Pharmaceutical industry (ESR A2.4)
5. Discuss change management issues associated with M&S adoption (ESR A2.5)
6. Discuss emerging CASE tool technologies and their contribution to corporate integration (ESR A2.6)

### *Course Assessment Plan*

Verbal Feedback during Class- to periodically check on students' understanding of topics taught

End-of-Course Test- general multiple choice questions on all topics taught

### Hour-by-hour Instruction

Hour 1: ESR A2.1: Identification of commercial acquisition strategies and terminology, Syllabus

Hour 2 & 3: ESR A2.2: Introduction to M&S benefits to commercial aircraft. Discussion of commercial case history of HOW M&S has been used to advance and sustain quality and distribute production world-wide by global commercial aircraft manufacturers from the foundation of aviation with the Wright brothers to the most current aircraft.

- \*Porter, HBR, March 1979
- \*Fuchs, et al CMR 2000
- \*Porter and Millar, HBR, July 85.
- \*Hamel & Prahalad, HBR, 2005
- \*Quinn, HBR 1967;
- \*Chambers, et al., HBR 1971;
- \*Georgoff & Murdick, HBR 1986

Hour 4 & 5: ESR A2.3: Introduction to M&S benefits to commercial automotive industries. Discussion of case history of recent radical changes in HOW M&S has been used by a Global Automotive Company to radically alter their entire software infrastructure, re-train their work force, rapidly close and then surpass other Global Automotive Commercial Companies through the productivity and time to market gains made possible through M&S

- \*Morgan, James M. and Liker, Jeffrey K., (2006) The Toyota Product Development System
- \*Ward, et al, Sloan Management Review, Spring 1995;
- \*Sobek, Liker & Ward, HBR July-August 1998;
- \*Spear & Bowen, HBR, 1999
- \*Thomke, MIT, 2006
- \*Thomke, HBR, 2001

- \*Thomke, Research Policy 27 (1998) 55-74;
- \*Goldhar & Jelink, HBR, 1983

Hour 6: ESR A2.4: Introduction to and discussion of M&S benefits to commercial Pharmaceutical industries,

- \*Raynor & Panetta, S&I, 2005
- \*Stermen, CMR, 2001
- \*Ring et al, CMR, 2005

Hour 7: ESR A2.5: Commercial case history of change management issues and approaches as it relates to M&S adoption and proliferation. Change management due to M&S tool adoption (45 hour course would have a 3 hour Student report and presentation)

- \*Susskind, Negotiation, 2005
- \*Harvard Update, 2000
- \*Bonabeau, 2002
- \*Kallio, et al Journal, 1999
- \*Sirkin, et al, HBR, 2005
- \*Malhotra, Negotiation, 2004

Hour 8: ESR A2.6: Commercial case history of the use of Computer Assisted System Engineering tools to describe the relationship within and between systems life cycles within a corporation and close gaps between those systems. Change emerging trends in CASE tool applications, Sectional Review, Conclusion, End-of-Course Test (45 hour course would have a 3 hour Student report and presentation)

- \*Contemporary articles

Course Name: Understanding Computer Technology and Army Training Modeling and Simulation (M&S) Applications in Support of Acquisition

*Course Coordinator*

Michael D. Proctor, Ph.D., LTC (Retired)

Associate Professor, CMSP

IEMS & IDS M&S

University of Central Florida

Engineering Building 2, Room 301-D

Tel: 407-823-5296

Fax: 407-823-3413

[mproctor@mail.ucf.edu](mailto:mproctor@mail.ucf.edu)

<http://people.cecs.ucf.edu/proctor>

*Course Description*

This course will provide an *understanding* of the theoretical fundamentals of basic computer system software tools and Army Training Modeling and Simulation applications that are used in support of acquisition. Exposure to practical Army training modeling and simulation (M&S) applications as system life cycle management tools in support of Simulation-based Acquisition (SBA) will be through cases.

*Modules incorporated into Course:*

This course incorporates ESR A2 material covered in the Awareness course (modules).

*ESR Supporting the Course*

ESR E8. Taught at understanding level of each sub ESR

*Pre-requisite*

1. Rank/Seniority:

Active Military: O-1 through O-4 and above

Government Civilian: GS-5 through GS-13 and above

2. Pre-Course/Training:

CLE011 and CLE023

*Course Maturity*

New course.

*Contact Hours / Pace of Completion*

This is a one-day seminar with 8 contact hours.

*Proposed Delivery Modality*

The course is a mixture of face-to-face teaching and will reuse the Awareness level content and the corresponding online course learning module if the online course (module) is developed.

### *Proposed Reference and Text*

- Case Study to be developed with PEO STRI on Live Training Simulation in Acquisition (OneTESS)
- Case Study to be developed with PEO STRI on Constructive Training Simulation in Acquisition (OneSAF Objective System)
- Case Study to be developed with IBM on Rational
- OUSD (AT&L) (2006). *Acquisition Modeling and Simulation Master Plan*. Department of Defense.
- Piplani Lalik, Mercer Joseph, Roop Richard (1994). *Systems Acquisition Manager's Guide for the Use of Models and Simulations*. Defense Systems Management College.
- Proctor (Editor) (1999) *Web-based Technical Reference on Simulation Interoperability*
- Proctor Michael, Posey-Macalintal Amy, Kulonda Dennis (2003). *Why the "T" in SMART: A Constructive Synergy*. Acquisition Review Quarterly Summer 2003: 285-299
- Proctor Michael, Lipinski Michael (2000). Technical Performance Measures and Distributed-Simulation Training Systems. Acquisition Review Quarterly Winter 2000: 19-32
- Sherman William, Craig Alan (2003). *Understanding Virtual Reality*. Morgan Kaufman Publishers.
- Woodridge Michael (2002). *Multiagent Systems*. John Wiley & Sons.

### *Course Learning Objectives*

Students who have successfully completed this course will be able to:

1. E8.1 Comprehends basic computer system architecture, operating systems, networking, introductory engineering software and their application to Modeling and Simulation (M&S) applications, introductory structured programming languages such as Fortran and C, and the use of such languages for software development
2. E8.2 Distinguishes the use of selected Runtime software systems to build M&S scenarios to support PMs, SEs, and T&E requirements across the acquisition life cycle.
3. E8.3 Comprehends the use of selected Intelligent Agent software systems to build M&S scenarios to support PMs, SEs, and T&E requirements across the acquisition life cycle.
4. E8.4 Comprehends M&S, interoperability, and intelligent agent software tools to build massively online systems (to include gaming systems) so as to support PMs, SEs, and T&E requirements across the acquisition life cycle.
5. E8.5 Comprehends alternative Live training M&S systems in support of training and T&E requirements across the acquisition life cycle.
6. E8.6 Comprehends alternative virtual training M&S systems in support PMs, SEs, and T&E requirements across the acquisition life cycle.
7. E8.7 Comprehends Computer Assisted System Engineering tools to support project life cycle development/engineering.

*Course Assessment Plan*

Verbal Feedback during Class- to periodically check on students' understanding of topics taught

End-of-Course Evaluation- via group discussion, presentation and sharing

Hour-by-hour Instruction

Hour 1: Comprehends basic computer systems, M&S tools for acquisition (E8.1)

Hour 2: Distinguishes Modeling Software, Runtime Software

Hour 3: Comprehends Intelligent Agent Software for acquisition (OneSAF, Mak VR Forces, SimBionic) (E8.3)

Above 3 hours supported by:

Case Study to be developed with PEO STRI on Constructive Training Simulation in Acquisition (OneSAF Objective System)

Piplani Lalik, Mercer Joseph, Roop Richard (1994). *Systems Acquisition Manager's Guide for the Use of Models and Simulations*. Defense Systems Management College.

OUSD (AT&L) (2006). *Acquisition Modeling and Simulation Master Plan*. Department of Defense.

Proctor (Editor) (1999) *Web-based Technical Reference on Simulation Interoperability*

Sherman William, Craig Alan (2003). *Understanding Virtual Reality*. Morgan Kaufman Publishers.

Woodridge Michael (2002). *Multiagent Systems*. John Wiley & Sons.

Hour 4: Comprehends massively online M&S Systems to include games for acquisition (E8.4)

Proctor (Editor) (1999) *Web-based Technical Reference on Simulation Interoperability*

Sherman William, Craig Alan (2003). *Understanding Virtual Reality*. Morgan Kaufman Publishers.

Woodridge Michael (2002). *Multiagent Systems*. John Wiley & Sons.

Hour 5: Comprehends potential for Live Training M&S for use in Acquisition (OneTESS) (E8.5)

Case Study to be developed with PEO STRI on Live Training Simulation in Acquisition (OneTESS)

Hour 6: Comprehends potential for Virtual Training M&S for Acquisition (CCTT) (E8.6)

Proctor Michael, Posey-Macalintal Amy, Kulonda Dennis (2003). *Why the "T" in SMART: A Constructive Synergy*. Acquisition Review Quarterly Summer 2003: 285-299

Proctor Michael, Lipinski Michael (2000). Technical Performance Measures and Distributed-Simulation Training Systems. Acquisition Review Quarterly Winter 2000: 19-32

Hour 7: Comprehends Computer Assisted System Engineering software applicability to acquisition (E8.7)

Case Study to be developed with IBM on Rational

Hour 8: Conclusion and End-of-Course Evaluation

## University of California, San Diego

- 1) Course name: Modeling, Simulation and Undersea Warfare
- 2) Course coordinator/POC: Anthony Genna  
UCSD Extension  
Assistant Director,  
Defense Technology  
agenna@ucsd.edu  
858-603-2170 (cell)
- 3) Course description: This course is designed to educate and introduce acquisition workforce professionals to modeling and simulation and its application to undersea warfare systems. The general focus of this course is to address the role of modeling and simulation and its application to the design, analysis and evaluation of acoustic undersea warfare systems. The specific focus of this course is to address the development of underwater communication, anti-submarine warfare, anti-ship torpedo defense, and mine warfare systems in a simulation based environment.
- 4) Modules incorporated into the course: E6.1, E6.3, E6.5,
- 5) ESR's that the course supports and the corresponding level of achievement:  
E6.1 (G, U)  
E6.3 (G, U, A, M)  
E6.5 (G, U, A, M)
- 6) Prerequisites: This course is designed for DoD military and civilian professionals who are determined to be proficient in modeling and simulation and its application to the design, analysis and evaluation of underwater acoustic warfare systems.
- 7) Course maturity: This is a new course based on a UCSD Underwater Acoustic specialty certificate. This course will support the continuing education of working acquisition professional with special interest in the field of underwater communications, anti-submarine warfare, anti-ship torpedo defense, and mine warfare.
- 8) Number of contact hours and pace contemplated: This 27 hour course will provide 3 CEU's. The Class will meet 3 hours per week for 9 weeks. The hour breakdown for each level of competency is provided below:
  - a) (G) General Awareness      2 hours (instruction)
  - b) (U) Understanding            4 hours (instruction and short quiz)
  - c) (A) Application            9 hours (5 hr inst.; 3hr field trip; Mid Term)
  - d) (M) Mastery                12 hours (5 hr inst.; 6 hr projects; Final)

9) Proposed Delivery modality: (face-to-face)

10) Proposed references and texts:

[1] Urick, Principles of Underwater Sound 3rd Edition

[2] Etter, Underwater Acoustics Modeling and Simulation: Principles, Techniques and Applications

[3] Active Acoustic Simulation Models such as Active System Performance Estimate Computer Tool (ASPECT),

[http://www.adaptivemethods.com/core\\_competencies/modeling\\_and\\_simulation.html](http://www.adaptivemethods.com/core_competencies/modeling_and_simulation.html)

[4] Navy Modeling and Simulation Office.

[https://nmso.navy.mil/NavyMSRR/Browse/tabid/85/Default.aspx?RID=MNS\\_N\\_1001157](https://nmso.navy.mil/NavyMSRR/Browse/tabid/85/Default.aspx?RID=MNS_N_1001157)

11) Course learning objectives:

E6.1 Define and identify the benefits of modeling and simulation and its application to acoustic wave propagation.

E6.3 Define and identify the benefits of modeling and simulation and its application to acoustic communication systems

E6.5 Define and identify the benefits of modeling and simulation and its application to acoustic active and passive detection systems

12) Course assessment plan:

1. Week 1 through week 9: Weekly quizzes or exam to test competency at corresponding level of instruction
2. Week 5: Mid term Exam to test student competency at the application level.
3. Week 6, 7, 8: Class projects to demonstrate student's ability to perform analysis and evaluation at the mastery level.
4. Week 9: Final exam to test student's ability to perform analysis and evaluation at the mastery level.

13) Topic list by hour of instruction and reference:

This 27 hour course is structured such that each hour is based on its required level of competency. This structure allows course material to be provided as four separate groupings: General Awareness; Understanding, Application, and Mastery.



General Awareness Skill Level:

- 1-2 Overview addressing the benefits of modeling and simulation applied to underwater communication, anti-submarine warfare, anti-ship torpedo defense, and mine warfare systems. Ref: [1], [2], instructor notes.

Understanding Skill Level:

- 3 Introduction to the application of modeling and simulation applied to underwater acoustic wave propagation. This section will address acoustic propagation computer simulation models such as: ASTRAL and IMAT simulation tools that utilize the METOC reference data base model. Ref. [1], [2], instructor notes.
- 4 Introduction of modeling and simulation applied to the development of underwater communication systems. This section will address the use of system prototyping in a simulation based virtual environment. Ref. [1], [2], instructor notes.
- 5 Introduction of modeling and simulation applied to development of underwater acoustic active anti-submarine warfare, anti-ship torpedo defense, and mine warfare systems. This section will address the use of system prototyping in a simulation based virtual environment. Ref. [1], [2], instructor notes.
- 6 Introduction of modeling and simulation applied to development of underwater acoustic passive detection systems. This section will address the use of system prototyping in a simulation based virtual environment. Ref. [1], [2], instructor notes.

Application Skill Level:

- 7 Application of modeling and simulation applied to underwater acoustic communication system models such as: to be provided by instructor. This section will address the application of system prototyping in a simulation based virtual environment. Ref [1], [2], instructor notes
- 8-9 Application of modeling and simulation applied to passive ASW acoustic systems. This underwater section will address the application of system prototyping in a simulation based virtual environment. Computer models such as ASPECT, Acoustic System Performance Model (ASPM) and other simulation models to be provided by the instructor. Ref: [1], [2], instructor notes.
- 10-12 Field Trip: 3 hour field trip to local DoD/contractor facility. For example; this field trip would be to the ASW Training facility in San Diego. Students would be able to witness actual system operation and interview operators with respect to their views on ASW system performance. Ref: [1], [2], instructor notes.
- 13-14 Application of modeling and simulation applied to underwater active acoustic ASW, anti-ship torpedo defense, and mine detection systems. This section will address the application of system prototyping in a simulation based virtual environment. Computer models such as ASPECT, Acoustic System Performance Model (ASPM) and other simulation models to be provided by the instructor. Ref: [1], [2], [3], [4], instructor notes.

- 15 Mid Term Exam to evaluate student competency at the application level. Ref. [1], [2], [3], instructor notes.

*Mastery Skill Level:*

- 16 Modeling and simulation techniques tailored to the analysis and evaluation of communication systems development. This section will focus on the benefits of system prototyping in a simulation based virtual environment. Instructor selected case studies will be provided. Ref. [1], [2], instructor notes.
- 17-18 Class team project: Select modeling and simulation techniques that can be applied to analysis and evaluation related to communications systems development. Ref. [1], [2], instructor notes.
- 19 Modeling and simulation techniques tailored to the analysis and evaluation of passive ASW acoustic systems. This section will focus on the benefits of system prototyping in a simulation based virtual environment. Instructor selected case studies will be provided. Ref. [1], [2], instructor notes.
- 20-21 Class team project: Determine and define modeling and simulation techniques that can be applied to analysis and evaluation of passive ASW acoustic systems. Ref. [1], [2], instructor notes.
- 22 Identify modeling and simulation techniques and show how they are used in the analysis and evaluation of underwater acoustic active anti-submarine warfare, anti-ship torpedo defense, and mine warfare systems. This section will focus on the benefits of system prototyping in a simulation based virtual environment. Instructor selected case studies will be provided. [1], [2], instructor notes.
- 23-24 Class Project: Identify the benefits of computer simulation tailored to underwater acoustic active anti-submarine warfare, anti-ship torpedo defense, and mine warfare systems. Ref. [1], [2], instructor notes.
- 25-26 Case Studies: Instructor to provide case studies that illustrate the benefits of modeling and simulation to the analysis and evaluation of underwater acoustic systems. This section will focus on communications, active/passive ASW and mine warfare. Ref: [1], [2], instructor notes.
- 27 Final exam to test student's ability to perform analysis and evaluation at the mastery level. Ref: [1], [2], instructor notes.

- 1) Course name: Modeling and Simulation Applied to Human Systems Integration
- 2) Course coordinator/POC: Anthony Genna  
UCSD Extension  
Assistant Director,  
Defense Technology  
agenna@ucsd.edu  
858-603-2170 (cell)
- 3) Course description: This course is designed to educate and introduce acquisition workforce professionals to modeling and simulation and its application to human systems engineering and human systems integration. The general focus of this course is to address the role of computer simulation relative to system operability performance and its impact on life cycle manpower projections. The specific focus of this course is to address the development of human system interfaces and the evaluation of those interfaces in a simulation based environment.
- 4) Modules incorporated into the course:  
UCSD: E13.1, E13.2, E13.4, E13.5
- 5) ESR's that the course supports and the corresponding level of achievement:  
UCSD E13.1 (G, U)  
UCSD E13.2 (G, U, A, M)  
UCSD E13.3 (G, U, A, M)  
UCSD E13.4 (G, U, A, M)  
UCSD E13.5 (G, U, A, M)
- 6) Prerequisites: This course is designed for DoD military and civilian professionals who are determined to be proficient in modeling and simulation and its application to the human systems engineering and human systems integration design and evaluation process.
- 7) Course maturity: This is a new course based on a UCSD HSI specialty certificate. This course will support the continuing education of working acquisition professional with special interest in the field of human systems engineering and human systems integration.
- 8) Number of contact hours and pace contemplated: This 36 hour course will provide 4 CEU's. The Class will meet 3 hours per week for 12 weeks. The hour breakdown for each level of competency is provided below:
  - a) General Awareness 3 hours
  - b) Understanding 5 hours
  - c) Application 13 hours (8 hr instruction; 2 hr project; 3 hr. field trip)
  - d) Mastery 15 hours (10 hr instruction; 2 hr project; 3 hr field trip)

9) Proposed Delivery modality: (face-to-face)

10) Proposed references and texts:

[1] Evaluation of Human Work, Third Edition. John R. Wilson and Nigel Corlett, Taylor and Francis, CRC press 2005.

[2] Handbook of Human Systems Integration, Harold R. Booher, Wiley & Sons, 2003.

[3] "Integrating Systems Engineering and Human Performance Models" , Air Force Research Lab Wright-Patterson AFB OH, Human Effectiveness Directorate.  
<http://stinet.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA430196>

Human Factors (HSI/HSE) References:

[4] MIL-STD-1472/ IDEA Hyperlink: The IDEA Hypertext Tool for MIL-STD-1472 (HT-1472) evolved from a demonstrated need to quickly locate and extract specific items of information from MIL-STD-1472, entitled "Human Engineering Design Criteria for Military Systems, Equipment and Facilities."

[5] MIL-STD-1472F establishes general human engineering criteria for design and development of military systems, equipment and facilities. Its purpose is to present human engineering design criteria, principles and practices to be applied in the design of systems, equipment and facilities so as to: a) achieve required performance by operator, control, and maintenance personnel; b) minimize skill and personnel requirements, and training time; c) achieve required reliability of personnel-equipment combinations; d) foster design standardization within and among systems.

[6] MIL-HDBK-759 Department of Defense Handbook for Human Engineering Design Guidelines, was being converted to a tri-service handbook including data removed from MIL-STD-1472D and the Air Force Systems Command (AFSC) Design Handbook (DH) 1-3

[7] MIL-HDBK-759C Department of Defense Handbook for Human Engineering Design Guidelines This handbook provides basic guidelines and data on human engineering design for military systems.

[8] MIL-HDBK-1908B This handbook consolidates definitions of terms used in Defense human factors standardization (HFAC) documents.

## 11) Course learning objectives:

E13.1 Define and identify the benefits of modeling and simulation and its application to human systems engineering and human systems integration.

E13.2 Define and identify analysis and evaluation methods related to the application of modeling and simulation tools applied to the ergonomic design process.

E13.3 Define and identify analysis and evaluation methods related to the application of modeling and simulation tools applied to the audio and visual design process.

E13.4 Define and identify analysis and evaluation methods related to the application of modeling and simulation tools applied to system operability.

E13.5 Define and identify human systems engineering and human systems integration analysis and evaluation methods based on the application of modeling and simulation tools to the life-cycle-cost (LCC) acquisition process.

## 12) Course assessment plan:

1. Week 1 through week 12: Weekly quizzes or exams to test competency at corresponding level of instruction
2. Week 7: Class project based on case study and class field trip to demonstrate competency at the application level.
3. Week 7: Mid term Exam to test student competency at the application level.
4. Week 12: Class project based on case study and class field trip to demonstrate students ability to perform analysis and evaluation at the mastery level.
5. Week 12: Final exam to test student's ability to perform analysis and evaluation at the mastery level.

## 13) Topic list by hour of instruction and reference:

This 36 hour course is structured such that each hour is based on its required level of competency. This structure allows course material to be provided as four separate groupings: General Awareness; Understanding, Application, and Mastery.

General Awareness Skill Level:

1-3 Overview of the benefits of modeling and simulation applied to the human systems engineering and human systems integration process. Ref: [1], [2], instructor notes.

Understanding Skill Level:

- 4 Introduction to the application of modeling and simulation applied to the human systems engineering and human systems integration process. Ref. [1], [2], instructor notes.
- 5 Introduction of modeling and simulation applied to the ergonomic design process. This section will address the use of Computer Aided Design (CAD) tools such as CATIA and 3D SIM models. Ref. [1], [2], instructor notes.
- 6 Introduction of modeling and simulation applied to the audio visual design process. This section will address the use of system prototyping in a simulation based virtual environment. Ref. [1], [2], instructor notes.
- 7 Introduction of modeling and simulation applied to system design and its impact on system operability. This section will address the use of system prototyping in a simulation based virtual environment. Ref. [1], [2], instructor notes.
- 8 Introduction of modeling and simulation applied to the impact of human systems engineering and human systems integration on life cycle cost (LCC). This section will address key elements of estimating manpower requirements and system survivability based on instructor provided case studies. [Ref. [1], [2], instructor notes.

Application Skill Level:

- 09-10 Application of modeling and simulation applied to ergonomic design. This section will address the application of Computer Aided Design (CAD) tools such as CATIA and 3D SIM models. Ref [1], [2], instructor notes
- 11-12 Application of modeling and simulation applied to audio visual design. This section will address the application of system prototyping in a simulation based virtual environment. Ref [1], [2], instructor notes
- 13-14 Application of modeling and simulation and prototyping to test and evaluate system operability. This section will address the application of system prototyping in a simulation based virtual environment. Ref. [1], [2], instructor notes.
- 15 Application of modeling and simulation applied to the life cycle cost (LCC) estimation process. This section will address key elements of estimating manpower requirements and system survivability based on instructor provided case studies. Ref. [1], [2], instructor notes.
- 16-18 Field Trip: 3 hour field trip to local DoD/contractor facility. For example this field trip would be to General Atomics in San Diego to witness a demonstration of the Predator UAV flight control system. Ref. [1], [2], [3], instructor notes.
- 19-20 Class Project: Determine and define the benefits of computer simulation based on instructor provided case studies and class field trip. Content will include but not be limited to system operability, ergonomics, visual performance, audio performance, background light and noise on system operation, and LCC.
- 21 Mid Term Exam: Evaluate student competency at the application level. Ref. [1], [2], [3], instructor notes.

*Mastery Skill Level:*

- 22 Modeling and simulation techniques tailored to the analysis and evaluation of ergonomic development. This section will focus on the benefits of system prototyping in a simulation based virtual environment. Instructor selected case studies will be provided. Ref. [1], [2], instructor notes.
- 23 Class team project: Select modeling and simulation techniques that can be applied to analysis and evaluation related to system ergonomics. Ref. [1], [2], instructor notes.
- 24 Modeling and simulation techniques tailored to the analysis and evaluation of audio visual design. Special attention will be placed on the impact of acoustic and visual noise on human performance. This section will focus on the benefits of system prototyping in a simulation based virtual environment. Instructor selected case studies will be provided. Ref. [1], [2], instructor notes.
- 25 Class team project: Determine and define modeling and simulation techniques that can be applied to analysis and evaluation related to audio and visual design. Ref. [1], [2], instructor notes.
- 26 Identify modeling and simulation techniques and show how they are used in the analysis and evaluation process related to system operability. This section will focus on the benefits of system prototyping in a simulation based virtual environment. Instructor selected case studies will be provided. [1], [2], instructor notes.
- 27 Class Project: Identify the benefits of computer simulation tailored to system operability recognizing and/or determining M&S solution for improved operability. Ref. [1], [2], instructor notes.
- 28 Select modeling and simulation techniques to the analysis and evaluation process related to human systems engineering and human systems integration and its impact on LCC. Ref. [1], [2], instructor notes.
- 29-30 Class Project: Determine and define the benefits of computer simulation tailored to the analysis and evaluation applied to LCC and recognizing and/or determining cost savings and risk mitigation in the acquisition decision process. This section will address key elements of estimating manpower requirements and system survivability Ref. [1], [2], instructor notes.
- 31-33 Field Trip: 3 hour field trip to local DoD/contractor facility. For example; this field trip would be to the ASW Training facility in San Diego. Students would be able to witness actual system operation and interview operators with respect to their views on system operability. Ref. [1], [2], instructor notes.
- 34-35 Class Team Project: Determine and define benefits of computer simulation tailored to the analysis and evaluation of system operability, ergonomics, visual performance, audio performance and the impact of noise and other operator distractions on system operation.
- 36 Final exam: Test student's ability to perform analysis and evaluation at the mastery level. Ref. [1], [2], instructor notes.

- 1) Course name: M&S in Decision Risk Analysis and Risk Mitigation
- 2) Course coordinator/POC: Anthony Genna  
UCSD Extension  
Assistant Director,  
Defense Technology  
agenna@ucsd.edu  
858-603-2170 (cell)
- 3) Course description: This course is designed to educate and introduce acquisition workforce professionals to modeling and simulation (M&S) and its application to Decision Risk Analysis and Risk Mitigation. This course will introduce the student to the concepts entailed in the use of M&S to make informed engineering tradeoff analyses through the program's Decision Risk Analysis process. General focus areas of this course include: application of experimental design, level of model detail, risk mitigation strategy development, evaluation of M&S outputs/measures, and M&S application as a pre-test prediction tool.
- 4) Modules incorporated into the course: A7, limited/modified P6.
- 5) ESR's that the course supports and the corresponding level of achievement:
  - A7.1 (G, U, A, M)
  - A7.2 (G, U, A, M)
  - A7.3 (G, U, A, M)
  - A7.4 (G, U, A, M)
  - A7.5 (G, U, A, M)
  - P6.6 (G, U, A, M)
- 6) Prerequisites: This course is designed for DoD military and civilian professionals who are determined to be proficient to the apprentice, journeyman or expert level (as applicable) in their current job positions in the areas of program management, systems engineering and/or test and evaluation.
- 7) Course maturity: This is a new course. There is a 5-day course on Decision and Risk Analysis (SYS/SDOE 660) available from Stevens Institute of Technology, but it presents the core topics differently than this course does.
- 8) Number of contact hours and pace contemplated: This 27 hour course will provide 3 CEU's. The class will meet 3 hours per week for 9 weeks. The hour breakdown for each level of competency is provided below:
  - a) General Awareness 3 hours
  - b) Understanding 4 hours
  - c) Application 9 hours (5 hr instruction; 3 hr project; 1 hr exam)
  - d) Mastery 11 hours (7 hr instruction; 3 hr project; 1 hr exam)



9) Proposed delivery modality: face-to-face.

10) Proposed references and texts:

[1] Risk Assessment and Decision Making in Business and Industry: a Practical Guide, by Glenn Koller, CRC Press, Boca Raton, Florida, 1999.

[2] Risk Management Guide for DoD Acquisition, 6<sup>th</sup> ed., V1.0, August 2006.  
<http://www.sei.cmu.edu/risk/dod-risk.pdf>

Additional useful references:

[3] OPNAVINST 5200.34, Navy Modeling and Simulation (M&S) Management, 28 May 2002.

[4] Simulation Based Acquisition: A New Approach, Report of the Military Research Fellows, DSMC, 1997-1998.

11) Course learning objectives:

A7.1: Develop pre-test criteria and analyze/apply choices of design detail for desired performance factors for a selected application.

A7.2: Analyze outputs/measures from M&S tools for a given case study.

A7.3: Evaluate performance factors and interdependencies of outputs/measures based on a given set of case studies.

A7.4: Identify and prioritize risk factors using the Decision Risk Analysis process.

P6.6: Develop a risk mitigation strategy for a given case study.

A7.5: Perform informed engineering tradeoff analyses through the Decision Risk Analysis process.

12) Course assessment plan:

1. Week 1 through week 9: Weekly quizzes to test competency at corresponding level of instruction.
2. Week 5: Class project based on case study to demonstrate students' ability to perform analysis at the application level.
3. Week 6: Mid term exam to test student competency at the application level.
4. Week 9: Class project based on case study to demonstrate students' ability to perform analysis and evaluation at the mastery level.
5. Week 9: Case study and final exam to test student's ability to perform analysis and evaluation at the mastery level.

### 13) Topic list by hour of instruction and reference:

The 27 hour course is structured such that each hour is based on its required level of competency. This structure allows the course material to be provided as four separate groupings: General Awareness, Understanding, Application, and Mastery.

#### General Awareness Skill Level:

- 1-3 Introduction and overview of informed engineering tradeoff analyses using a Decision Risk Analysis process. A7.1-A7.5, P6.6. Ref: [1], [2], instructor notes.

#### Understanding Skill Level:

- 4 Definition of pre-test criteria and application of design detail choices for desired performance factors for a selected application. A7.1. Ref: [1], [2], instructor notes.
- 5 Identification of outputs/measures, interdependencies and performance factors related to M&S tools. A7.2, A7.3. Ref: [1], [2], instructor notes.
- 6 Identification and prioritization of risk factors using a Decision Risk Analysis process. Identify critical elements required to develop exceptional system risk mitigation strategies. A7.4, P6.6. Ref: [1], [2], instructor notes.
- 7 Examples of how a Decision Risk Analysis process enables informed engineering tradeoff analysis. A7.5. Ref: [1], [2], instructor notes.

#### Application Skill Level:

- 8 Use of M&S applications to develop pre-test criteria and analyze/apply choices of design detail for desired performance factors for a selected application. A7.1. Ref: [1], [2], instructor notes.
- 9 Use of M&S applications to analyze outputs/measures from M&S tools for a given case study. A7.2. Ref: [1], [2], instructor notes.
- 10 Use of M&S applications to evaluate performance factors and interdependencies of outputs/measures for a given case study. A7.3. Ref: [1], [2], instructor notes.
- 11 Use of M&S applications to identify and prioritize risk factors using a Decision Risk Analysis process. A7.4. Ref: [1], [2], instructor notes.
- 12 Use of M&S application techniques that support risk mitigation. P6.6. Ref: [1], [2], instructor notes.
- 13-15 Class team project: Perform informed engineering tradeoff analyses through a Decision Risk Analysis process. Apply modeling and simulation techniques to risk analysis and risk mitigation. A7.5. Ref: [1], [2], instructor notes.
- 16 Mid term exam to evaluate student competency at the application level. Ref: [1], [2], instructor notes.

*Mastery Skill Level:*

- 17-18 Use of M&S tools to support analysis and application of choices of design detail for desired performance factors. Includes instructor-selected case studies. A7.1. Ref: [1], [2], instructor notes.
- 19 Use of M&S tools in support of analysis of M&S outputs/measures. Includes instructor-selected case studies. A7.2. Ref: [1], [2], instructor notes.
- 20-21 Use of M&S tools in support of analysis and evaluation of performance factors and interdependencies of outputs/measures for a given case study. A7.3. Ref: [1], [2], instructor notes.
- 22-23 Use of M&S tools to identify and prioritize risk factors using a Decision Risk Analysis process. A7.4. Ref: [1], [2], instructor notes.
- 24 Use of M&S application techniques that support risk mitigation. P6.6. Ref: [1], [2], instructor notes.
- 25-26 Class team project: Evaluation of informed engineering tradeoff analyses through a Decision Risk Analysis process. Includes instructor-selected case studies. A7.5. Ref: [1], [2], instructor notes.
- 27 Final exam to test student's ability to perform analysis and evaluation at the mastery level. Ref: [1], [2], instructor notes.

- 1) Course name: Modeling and Simulation Strategy and Support Plans
- 2) Course coordinator/POC: Anthony Genna  
UCSD Extension  
Assistant Director,  
Defense Technology  
agenna@ucsd.edu  
858-603-2170 (cell)
- 3) Course description: This course is designed to educate and introduce acquisition workforce professionals to modeling and simulation (M&S) and its application to M&S planning and the generation of support plan documents. The general focus of this course is to define and identify the benefits of M&S and its application to the understanding, use and evaluation of M&S planning. The general focus of this course includes: development of an integrated Simulation Support Plan (SSP), System Engineering Plan (SEP), and Test and Evaluation Master Plan (TEMP). Specific focus areas include: the M&S planning process and its relationship to life cycle phases of development and acquisition milestone decisions; program cost, schedule and performance considerations; trade-off decisions; and effectiveness assessment.
- 4) Modules incorporated into the course: P6 (partial); P7 (partial).
- 5) ESR's that the course supports and the corresponding level of achievement:
  - P6.1 (G, U, A, M)
  - P6.2 (G, U, A, M)
  - P6.3 (G, U, A, M)
  - P6.4 (G, U, A, M)
  - P6.5 (G, U, A, M)
  - P7.1 (G, U, A, M)
  - P7.2 (G, U, A, M)
  - P7.3 (G, U, A, M)
  - P7.7 (G, U, A, M)
  - P7.8 (G, U, A, M)
  - P7.9 (U, A, M)
- 6) Prerequisites: This course is designed for DoD military and civilian professionals who are determined to be proficient to the apprentice, journeyman or expert level (as applicable) in their current job positions in the areas of program management, systems engineering and/or test and evaluation.
- 7) Course maturity: This is a new course. The M&S University of the MSAIC offers several courses with similar basic content to this one. In particular, the M&S Staff Officers Course and Simulation Support Plan Tutorial are complimentary.

8) Number of contact hours and pace contemplated: This 36 hour course will provide 4 CEU's. The class will meet 3 hours per week for 12 weeks. The hour breakdown for each level of competency is provided below:

- |    |                   |  |
|----|-------------------|--|
| a) | General Awareness | 3 hours  |
| b) | Understanding     | 6 hours  |
| c) | Application       | 12 hours (9 hr instruction; 2 hr project, 1 hr exam) |
| d) | Mastery           | 15 hours (9 hr instruction; 5 hr project, 1 hr exam) |

9) Proposed delivery modality: face-to-face.

10) Proposed references and texts:

- [1] Acquisition M&S Master Plan, 17Apr06  
[http://www.acq.osd.mil/sse/as/docs/AMSMP\\_041706\\_FINAL2.pdf](http://www.acq.osd.mil/sse/as/docs/AMSMP_041706_FINAL2.pdf)  
 [2], [3], [4] Decision Support Guidebook  
<https://akss.dau.mil/dag/GuideBook/PDFs/GBNov2006.pdf>  
 [3] Defense Acquisition Guidebook  
<https://akss.dau.mil/dag/> or  
<https://akss.dau.mil/dag/DoD5000.asp?view=document&doc=2>  
 [4] Systems Engineering Plan Preparation Guide  
[http://www.acq.osd.mil/sse/docs/SEP-Prep-Guide-Ver-2-0\\_18Oct07.pdf](http://www.acq.osd.mil/sse/docs/SEP-Prep-Guide-Ver-2-0_18Oct07.pdf)

Additional useful references:

- [5] DA PAM 5-12, Simulation Support Planning and Plans, 2 March 2005  
[http://www.army.mil/usapa/epubs/pdf/p5\\_12.pdf](http://www.army.mil/usapa/epubs/pdf/p5_12.pdf)  
 [6] Australian DoD Life Cycle Simulation Guide  
<http://www.defence.gov.au/capability/adso/docs/Requirements%20Phase%20Guide.pdf>  
 [7] Integrated Master Plan and Schedule  
[http://www.acq.osd.mil/sse/docs/IMP\\_IMS\\_Guide\\_v9.pdf](http://www.acq.osd.mil/sse/docs/IMP_IMS_Guide_v9.pdf)

11) Course learning objectives:

- P7.1: Define a Simulation Support Plan (SSP) and the relationship to using M&S for acquisition decisions.  
 P6.1: Relate acquisition cost models to M&S planning.  
 P6.3: Define cost requirements and justifications as they relate to an M&S plan/SSP.  
 P6.4: Develop a schedule for an M&S plan/SSP.  
 P6.2: Define measurable performance factors for a given case study.  
 P6.5: Assess effectiveness (cost and schedule) of an M&S plan/SSP.  
 P7.3: Show how an integrated SSP, SEP and TEMP can be leveraged to reduce risk, cost and schedule issues.  
 P7.2: Understand and describe efficient use of M&S planning across life cycle phases of development.

P7.8: Manage M&S resources and documentation of SSP, SEP and TEMP.

P7.7: Analyze the rationale for trade-off decisions and selections for SSP, SEP and TEMP strategies.

P7.9: Create and analyze a case study encompassing SSP, SEP and TEMP concepts.

## 12) Course assessment plan:

1. Week 1 through week 12: Weekly quizzes to test competency at corresponding level of instruction.
2. Week 7: Class project based on case study to demonstrate students' ability to perform at the application level.
3. Week 7: Mid term exam to test student competency at the application level.
4. Weeks 11 and 12: Class projects based on case studies to demonstrate students' ability to perform analysis and evaluation at the mastery level.
5. Week 12: Final exam to test student's ability to perform analysis and evaluation at the mastery level.

## 13) Topic list by hour of instruction and reference:

The 36 hour course is structured such that each hour is based on its required level of competency. This structure allows the course material to be provided as four separate groupings: General Awareness, Understanding, Application, and Mastery.

### General Awareness Skill Level:

- 1-3 Introduction and overview of a Simulation Support Plan (SSP), or M&S plan, and its relationship to using M&S to enable informed acquisition decisions. Introduction and overview of the M&S plan process and documents, such as a System Engineering Plan (SEP) and a Test and Evaluation Master Plan (TEMP). Ref: [1], [2], [3], [4], instructor notes.

### Understanding Skill Level:

- 4 Develop steps and objectives of the M&S planning process. Define details of an SSP, and considerations for its incorporation into an SEP and a TEMP. P7.1, to P7.9. Ref: [1], [2], [3], [4], instructor notes.
- 5 Understanding and development of M&S cost models, cost requirements and their justifications. Develop and define the fundamentals of an M&S scheduling and risk mitigation plan. P6.1, P6.3, P6.4. Ref: [1], [2], [3], [4], instructor notes.
- 6 Develop and define performance factors and system design measures that are candidates for simulation. Define the use of an SSP across life cycle phases of development. P6.2, P7.2. Ref: [1], [2], [3], [4], instructor notes.
- 7 Develop an understanding and illustrate how an integrated SSP, SEP and TEMP can be leveraged to reduce risk, cost, and schedule issues. Define the benefits and

- use of M&S resource management and related documentation. P7.3, P7.8. Ref: [1], [2], [3], [4], instructor notes.
- 8 Develop an understanding of how to perform M&S plan effectiveness assessment. This section includes, but is not limited to: metrics, reuse, integration/interoperability, verification/validation, and uncertainty considerations. P6.5. Ref: [1], [2], [3], [4], instructor notes.
- 9 Understanding of trade-off decisions and their rationale. P7.7. Ref: [1], [2], [3], [4], instructor notes.

*Application Skill Level:*

- 10 Identify and apply a process that supports the development of M&S planning documents and cost considerations. Apply the M&S planning process to acquisition milestones and decisions. P7.1, P6.1. Ref: [1], [2], [3], [4], instructor notes.
- 11-12 Identify and apply a process that supports the development of M&S planning techniques that include cost requirements and their justification in decision-making. Identify and apply a process that supports the development of M&S plan scheduling. P6.3, P6.4. Ref: [1], [2], [3], [4], instructor notes.
- 13 Identify a process that supports the development of measurable, effective M&S assessment plans - documenting and reporting on program milestone goals, progress, performance factors, decisions made, and achievement of objectives. Identify and apply M&S resource management best practices. P6.2, P7.8. Ref: [1], [2], [3], [4], instructor notes.
- 14-15 Identify and apply a process that supports the development of M&S planning techniques related to cost, schedule and program risk reduction, using an integrated SSP, SEP and TEMP. Apply the integrated SSP across life cycle phases of development to support capabilities-based and simulation-based acquisition initiatives, principles and policy. P7.3, P7.2. Ref: [1], [2], [3], [4], instructor notes.
- 16-18 Identify and apply a process that supports the development of M&S plan effectiveness assessment. Define and apply M&S planning processes related to appraisal of trade-off decisions and their rationale. P6.5, P7.7. Ref: [1], [2], [3], [4], instructor notes.
- 19-21 Class team project: Create an M&S plan development case study encompassing an SSP, SEP and TEMP. P7.9. Ref: [1], [2], [3], [4], instructor notes.
- 22 Mid term exam to evaluate student competency at the application level. Ref: [1], [2], [3], [4], [3], instructor notes.

*Mastery Skill Level:*

- 22 Identify and define a process that supports analysis and evaluation of M&S planning documents and cost considerations. Asses the M&S planning process as it relates to acquisition milestones and decisions. P6.1, P7.1. Ref: [1], [2], [3], [4], instructor notes.

- 23-24 Identify and define a process/processes that supports/support analysis and evaluation of M&S planning to determine cost, schedule and performance requirements and assessment metrics. P6.3, P6.4. Ref: [1], [2], [3], [4], instructor notes.
- 25 Identify and define a process that supports analysis and evaluation of M&S planning techniques for determining measurable performance factors for a given set of objectives. Identify and asses M&S planning techniques related to M&S resource management and documentation. P6.2, P7.8. Ref: [1], [2], [3], [4], instructor notes.
- 26-27 Identify and define a process that supports analysis and evaluation of how an integrated SSP can reduce cost, schedule and program risks based on instructor-provided case studies. Apply the integrated SSP across life cycle phases of development to support capabilities-based and simulation-based acquisition initiatives, principles and policy. P7.3, P7.2. Ref: [1], [2], [3], [4], instructor notes.
- 28-29 Identify and define a process that supports analysis and evaluation of trade-off decisions and their rationale in the M&S planning process, based on instructor-provided case studies. P7.7. Ref: [1], [2], [3], [4], instructor notes.
- 30-31 Identify and define a process that supports analysis and evaluation of M&S plan effectiveness (in a class project). P6.5. Ref: [1], [2], [3], [4], instructor notes.
- 32-33 Class team project: Analysis and evaluation (critique) of the M&S plan development case study created during class hours 19-20, encompassing an SSP, SEP and TEMP. P7.9. Ref: [1], [2], [3], [4], instructor notes.
- 34-35 Class project: Evaluate the soundness of the M&S plan details in two instructor-provided case studies. Provide recommended improvements for any weaknesses identified. P7.9. Ref: [1], [2], [3], [4], instructor notes.
- 36 Final exam to evaluate student competency at the mastery level. Ref: [1], [2], [3], [4], instructor notes.



- 1) Course name: Modeling, Simulation, Circuits & AC/DC Power Applications
- 2) Course coordinator/POC: Anthony Genna  
UCSD Extension  
Assistant Director,  
Defense Technology  
agenna@ucsd.edu  
858-603-2170 (cell)
- 3) Course description: This course is designed to educate and introduce acquisition workforce professionals to modeling and simulation and its application to electronic circuits and AC/DC power applications. The general focus of this course is to addresses the role of modeling simulation and its relationship to circuit design and AC/DC power applications. Specific attention is placed on AC/DC power systems and their relationship to shore-based, sea-based, and space-based applications in a simulation based environment.
- 4) Modules incorporated into the course: E9.1 –E9.4
- 5) ESR's that the course supports and the corresponding level of achievement:
  - E9.1 (G, U)
  - E9.2 (G, U, A)
  - E9.3 (G, U, A, M)
  - E9.4 (G, U, A, M)
- 6) Prerequisites: This course is designed for DoD military and civilian professionals determined to be proficient in modeling and simulation and its application to the design, analysis and evaluation of circuit design and AC/DC power applications..
- 7) Course maturity: This is a new course based on a UCSD circuit design specialty certificate. This course will support the continuing education of working acquisition professional with special interest in the field of circuit design and AC/DC power applications.
- 8) Number of contact hours and pace contemplated: This 27 hour course will provide 3 CEU's. The Class will meet 3 hours per week for 9 weeks. The hour breakdown for each level of competency is provided below:
  - a) (G) General Awareness      2 hours (instruction)
  - b) (U) Understanding            4 hours (instruction and short quiz)
  - c) (A) Application            10 hours (10 hr inst. Including class project and Mid Term)
  - d) (M) Mastery                11 hours (8 hr inst. 2 hr project; Final)
- 9) Proposed Delivery modality: (face-to-face)

## 10) Proposed references and texts:

[1] Analog and Digital Circuits for Electronic Control Systems Applications describes sensors, I/O signals, how to deal with them, and the operations of embedded microcontrollers. It has real-world examples and author Gerald Luecke leads the reader through a hands-on project, using the TI MSP430 microcontroller. An accompanying CD contains application notes, code for software examples and problem solutions. ISBN 0750678100

[2] Spice v.5 Electronic Circuit Simulation Software. <http://www.beigebag.com/>

[3] CMOS: Circuit Design, Layout, and Simulation, 2nd Edition  
R. Jacob Baker

[4] 2005 NASA/DoD UAPT Program Review, Integrated Power Management, Dr. Nathan Brooks, Florida A&M University.  
[http://www.asdl.gatech.edu/teams/ureti/AnnualReview2005/D2\\_10\\_2.5.2\\_Power\\_Brooks.pdf](http://www.asdl.gatech.edu/teams/ureti/AnnualReview2005/D2_10_2.5.2_Power_Brooks.pdf)

## 11) Course learning objectives:

E9.1 Define and identify the benefits of modeling and simulation and its application to the design and analysis of basic AC and DC circuits.

E9.2 Define and identify the benefits of modeling and simulation and its application to AC and DC motors and power distribution. This includes: construction and operating characteristics of rotating machinery, static converters, power distribution systems and multi-phased circuits.

E9.3 Define and identify the benefits of modeling and simulation and its application tools that are used to perform system trade-off's between AC and DC motors and power distribution systems. This includes: construction and operating characteristics of rotating machinery, static converters, power distribution systems and multi-phased circuits

E9.4 Define and identify the benefits of modeling and simulation and application tools used to evaluate military AC and DC motors and power distribution systems. This includes: construction and operating characteristics of rotating machinery, static converters, power distribution systems and multi-phased circuits. The specific focus is on AC/DC power systems related to shore-based, sea-based, and space-based applications in a simulation based environment

## 12) Course assessment plan:

1. Week 1 through week 9: Weekly quizzes or exam to test competency at corresponding level of instruction

2. Week 5: Mid term Exam to test student competency at the application level.
3. Week 6, 7, 8: Class projects to demonstrate student's ability to perform analysis and evaluation at the mastery level.
4. Week 9: Final exam to test student's ability to perform analysis and evaluation at the mastery level.

13) Topic list by hour of instruction and reference:

This 27 hour course is structured such that each hour is based on its required level of competency. This structure allows course material to be provided as four separate groupings: General Awareness; Understanding, Application, and Mastery.

General Awareness Skill Level (E9.1-E9.4):

1-2 Overview of the benefits of modeling and simulation applied to basic circuit analysis including DC and AC circuits. Describe the construction and operating characteristics of rotating machinery, static converters, power distribution systems and multi-phased circuits. Overview of electronic circuit design and AC/DC power systems related to shore-based, sea-based, and space-based applications in a simulation based environment. Identification of Simulation tools that include: Simulink/SimPowerSystems; PSCAD/EMTDC; and PowerSim (PSIM). Ref: [1], [2], instructor notes.

Understanding Skill Level (E9.1-E9.4):

- 7 Introduction to the application of modeling and simulation applied to the design and analysis of basic AC and DC circuits. This section will address the design and analysis of basic AC and DC circuit's computer simulation models to be provided by the instructor. Ref. [1], [2], instructor notes.
- 8 Introduction of modeling and simulation applied to the development, construction and operating characteristics of rotating machinery, static converters, power distribution systems and multi-phased circuits. Identification of Simulation tools that include: Simulink/SimPowerSystems; PSCAD/EMTDC; and PowerSim (PSIM). This section will address the use of system prototyping in a simulation based virtual environment. Ref. [1], [2], instructor notes.
- 9 Demonstrate basic understanding of M&S tools used to perform system trade-off's between ac/dc motors and power distribution systems. This includes the construction and operating characteristics of rotating machinery, static converters, power distribution systems and multi-phased circuits. This section will address the use of system prototyping in a simulation based virtual environment. Ref. [1], [2], instructor notes.
- 10 Introduction of modeling and simulation applied to development of ac/dc power systems related to shore-based, sea-based, and space-based applications in a

simulation based environment. This section will address the use of system prototyping in a simulation based virtual environment. Ref. [1], [2], instructor notes.

Application Skill Level (E9.2 E9.3, E9.4):

- 7 Application of modeling and simulation applied to ac/dc motors and power distribution system development. This includes the construction and operating characteristics of rotating machinery, static converters, power distribution systems and multi-phased circuits. This section will address the application of system prototyping in a simulation based virtual environment. Ref [1], [2], instructor notes
- 8-10 Application of modeling and simulation to perform system trade-off's between ac/dc motors and power distribution systems. Construction and operating characteristics of rotating machinery, static converters, power distribution systems and multi-phased circuits. This section will address the application of system prototyping in a simulation based virtual environment. Identification and use of simulation tools that include: Simulink/SimPowerSystems; PSCAD/EMTDC; and PowerSim (PSIM). Other simulation models to be provided by instructor. Ref: [1], [2], instructor notes.
- 10-12 Case Studies: ac/dc motors and power distribution systems. This includes the construction and operating characteristics of rotating machinery, static converters, power distribution systems and multi-phased circuits. Ac/dc power systems related to shore-based, sea-based, and space-based applications in a simulation based environment. Identification and use of Simulation tools that include: Simulink/SimPowerSystems; PSCAD/EMTDC; and PowerSim (PSIM). Ref: [1], [2], instructor notes.
- 13-15 Class Projects: Application of modeling and simulation applied to ac/dc motors and power distribution systems. This includes the construction and operating characteristics of rotating machinery, static converters, power distribution systems and multi-phased circuits. Ac/dc power systems related to shore-based, sea-based, and space-based applications in a simulation based environment. Identification and use of Simulation tools that include: Simulink/SimPowerSystems; PSCAD/EMTDC; and PowerSim (PSIM). Mid Term Exam to evaluate student competency at the application level. Ref. [1], [2], [3], instructor notes.

Mastery Skill Level (E9.3, E9.4):

- 15-19 Modeling and simulation techniques tailored to the analysis and evaluation of AC and DC motors and power distribution system development. This includes the construction and operating characteristics of rotating machinery, static converters, power distribution systems and multi-phased circuits. AC/DC power systems related to shore-based, sea-based, and space-based applications in a simulation based environment. A list of selected simulation tools include: Simulink/SimPowerSystems; PSCAD/EMTDC; and PowerSim (PSIM). This section will focus on the benefits of system prototyping in a simulation based

- virtual environment. Instructor selected case studies will be provided. Ref. [1], [2], instructor notes.
- 20-22 Class team project: determine and define modeling and simulation techniques that can be applied to analysis and evaluation of ac/dc motors and power distribution system development. This includes the construction and operating characteristics of rotating machinery, static converters, power distribution systems and multi-phased circuits. Ref. [1], [2], instructor notes.
- 23 Identify modeling and simulation techniques and show how they are used in the analysis and evaluation of ac/dc power systems related to shore-based, sea-based and space-based applications in a simulation based environment. This section will focus on the benefits of system prototyping in a simulation based virtual environment. A list of selected simulation tools include: Simulink/SimPowerSystems; PSCAD/EMTDC; and PowerSim (PSIM). [1], [2], instructor notes.
- 23-24 Case Studies: Instructor to provide case studies that illustrate trade-off analysis and the benefits of modeling and simulation to the analysis and evaluation of ac/dc power systems related to shore-based, sea-based, and space-based applications in a simulation based environment. This includes construction and operating characteristics of rotating machinery, static converters, power distribution systems and multi-phased circuits. Ref: [1], [2], instructor notes.
- 25-26 Class Project: Identify the benefits of modeling and simulation to the analysis and evaluation of ac/dc power systems related to shore-based, sea-based, and space-based applications in a simulation based environment. This includes construction and operating characteristics of rotating machinery, static converters, power distribution systems and multi-phased circuits. Ref. [1], [2], instructor notes.
- 27 Final exam to test student's ability to perform analysis and evaluation at the mastery level. Ref: [1], [2], instructor notes.

- 1) Course name: Modeling, Simulation, Communications & Electronic Warfare
- 2) Course coordinator/POC: Anthony Genna  
UCSD Extension  
Assistant Director,  
Defense Technology  
agenna@ucsd.edu  
858-603-2170 (cell)
- 3) Course description: This course is designed to educate and introduce the acquisition workforce professionals to modeling and simulation and its application to electronic and electromagnetic warfare systems. The general focus of this course is to address the role of modeling and simulation and its application to design, analysis and evaluation of electromagnetic warfare systems. The specific focus of this course is to address the development and analysis of communication, anti-missile warfare and electronic (EW) warfare systems in a simulation based environment.
- 4) Modules incorporated into the course: E6.2, E6.4, E6.6,
- 5) ESR's that the course supports and the corresponding level of achievement:  
E6.1 (G, U)  
E6.3 (G, U, A, M)  
E6.5 (G, U, A, M)
- 6) Prerequisites: This course is designed for DoD military and civilian professionals determined to be proficient in modeling and simulation and its application to the design, analysis and evaluation of electromagnetic warfare systems.
- 7) Course maturity: This is a new course based on a UCSD radar and electromagnetic specialty certificate. This course will support the continuing education of working acquisition professional with special interest in the field of communications, radar, anti-missile warfare, and electronic (EW) warfare.
- 8) Number of contact hours and pace contemplated: This 27 hour course will provide 3 CEU's. The Class will meet 3 hours per week for 9 weeks. The hour breakdown for each level of competency is provided below:
  - a) (G) General Awareness 2 hours (instruction)
  - b) (U) Understanding 4 hours (instruction and short quiz)
  - c) (A) Application 9 hours (5 hr inst.; 3hr field trip; Mid Term)
  - d) (M) Mastery 12 hours (5 hr inst.; 6 hr projects; Final)
- 9) Proposed Delivery modality: (face-to-face)
- 10) Proposed references and texts:

[1] Merrill Ivan Skolnik, Radar Handbook, "Radar is an electromagnetic system for the detection and location of reflecting objects such as aircraft, ships, spacecraft, vehicles, people, and the natural environment

[2] Adamy, David; Introduction to Electronic Warfare Modeling and Simulation

[3] LTJG Baris Ozkan, Neil C. Rowe, LT Sharif H. Calfee, and John E. Hiles  
Institute for Modeling, Virtual Environments, and Simulation (MOVES)  
and Computer Science Department, U.S. Naval Postgraduate School

[4] Navy Modeling and Simulation Office.  
[https://nmso.navy.mil/NavyMSRR/Browse/tabid/85/Default.aspx?RID=MNS\\_N\\_1001157](https://nmso.navy.mil/NavyMSRR/Browse/tabid/85/Default.aspx?RID=MNS_N_1001157)

[5] Agilent Technologies / Remcom, Electromagnetic Computer Simulation Models  
<http://www.remcom.com/consulting.html>

[6] ARNIC, Annapolis, MD, Electromagnetic Computer Simulation Models  
[http://www.arinc.com/products/modeling\\_simulation/electromagnetic\\_mod\\_sim.html](http://www.arinc.com/products/modeling_simulation/electromagnetic_mod_sim.html)

#### 11) Course learning objectives:

E6.2 Define and identify the benefits of modeling and simulation and its application to electromagnetic wave propagation.

E6.4 Define and identify the benefits of modeling and simulation and its application to electromagnetic communication systems.

E6.6 Define and identify the benefits of modeling and simulation and its application to electromagnetic active and passive detection systems.

#### 12) Course assessment plan:

1. Week 1 through week 9: Weekly quizzes or exam to test competency at corresponding level of instruction
2. Week 5: Mid term Exam to test student competency at the application level.
3. Week 6, 7, 8: Class projects to demonstrate student's ability to perform analysis and evaluation at the mastery level.
4. Week 9: Final exam to test student's ability to perform analysis and evaluation at the mastery level.

#### 13) Topic list by hour of instruction and reference:

This 36 hour course is structured such that each hour is based on its required level of competency. This structure allows course material to be provided as four separate groupings: General Awareness; Understanding, Application, and Mastery.

General Awareness Skill Level:

- 1-2 Overview addressing the benefits of modeling and simulation applied to communication, radar, anti-missile warfare electromagnetic warfare systems. Ref: [1], [2], instructor notes.

Understanding Skill Level:

- 11 Introduction to the application of modeling and simulation applied to electromagnetic wave propagation. This section will address electromagnetic propagation computer simulation models such as: Electromagnetic Propagation Integrated Resource Environment (EMPIRE), Advanced Propagation Model (APM), and others to be provided by the instructor. Ref. [1], [2], instructor notes.
- 12 Introduction of modeling and simulation applied to the development of communication systems. This section will address the use of system prototyping in a simulation based virtual environment. Ref. [1], [2], instructor notes.
- 13 Introduction of modeling and simulation applied to development of active radar and anti-missile warfare systems. This section will address the use of system prototyping in a simulation based virtual environment. Ref. [1], [2], instructor notes.
- 14 Introduction of modeling and simulation applied to development of electromagnetic warfare (EW) systems. This section will address the use of system prototyping in a simulation based virtual environment. Ref. [1], [2], instructor notes.

Application Skill Level:

- 7 Application of modeling and simulation applied to electromagnetic communication system models such as: to be provided by instructor. This section will address the application of system prototyping in a simulation based virtual environment. Ref [1], [2], instructor notes
- 8-11 Application of modeling and simulation applied to passive electromagnetic (EW) systems. This section will address the application of system prototyping in a simulation based virtual environment. Simulation models to be provided by instructor. Ref: [1], [2], instructor notes.
- 10-12 Field Trip: 3 hour field trip to local DoD/contractor facility. For example; this field trip would be to a missile defense modeling and simulation facility. Students would be able to witness actual system operation and interview modeling and simulation engineers with respect to their views system performance. Ref: [1], [2], instructor notes.
- 13-16 Application of modeling and simulation applied to anti-missile and electromagnetic (EW) warfare detection systems. This section will address the



- application of system prototyping in a simulation based virtual environment. Computer models such as: Electromagnetic Propagation Integrated Resource Environment (EMPIRE), other simulation models to be provided by the instructor. Ref: [1], [2], [3], [4], instructor notes.
- 17 Mid Term Exam to evaluate student competency at the application level. Ref. [1], [2], [3], instructor notes.

*Mastery Skill Level:*

- 18 Modeling and simulation techniques tailored to the analysis and evaluation of communication systems development. This section will focus on the benefits of system prototyping in a simulation based virtual environment. Instructor selected case studies will be provided. Ref. [1], [2], instructor notes.
- 17-19 Class team project: Select modeling and simulation techniques that can be applied to analysis and evaluation related to communications systems. Ref. [1], [2], instructor notes.
- 20 Modeling and simulation techniques tailored to the analysis and evaluation of electromagnetic (EW) systems. This section will focus on the benefits of system prototyping in a simulation based virtual environment. Instructor selected case studies will be provided. Ref. [1], [2], instructor notes.
- 20-23 Class team project: Determine and define modeling and simulation techniques that can be applied to analysis and evaluation of electronic (EW) warfare systems. Ref. [1], [2], instructor notes.
- 24 Identify modeling and simulation techniques and show how they are used in the analysis and evaluation of radar, anti-missile warfare and electromagnetic (EW) warfare systems. This section will focus on the benefits of system prototyping in a simulation based virtual environment. Instructor selected case studies will be provided. [1], [2], instructor notes.
- 23-25 Class Project: Identify the benefits of computer simulation tailored to active radar, anti-missile warfare electromagnetic warfare systems. Ref. [1], [2], instructor notes.
- 25-26 Case Studies: Instructor to provide case studies that illustrate the benefits of modeling and simulation to the analysis and evaluation of electromagnetic systems. This section will focus on communications, radar, anti-missile warfare and electromagnetic (EW) warfare. Ref: [1], [2], instructor notes.
- 27 Final exam to test student's ability to perform analysis and evaluation at the mastery level. Ref: [1], [2], instructor notes.

- 1) Course name: Methods Used to Create an Effective Modeling and Simulation Study
- 2) Course coordinator/POC: Anthony Genna  
UCSD Extension  
Assistant Director,  
Defense Technology  
agenna@ucsd.edu  
858-603-2170 (cell)
- 3) Course description: This course is designed to educate and introduce the acquisition workforce professionals to modeling and simulation (M&S) and its application to the concepts, considerations and elements required for creating a successful simulation study. Specific focus areas include problem formulation, experiment objectives, conceptualization of the simulation model, identifying input and output data, verification and validation, measures of performance, and analysis of both production runs and the overall simulation study plan along with the simulation results.
- 4) Modules incorporated into the course: P12.
- 5) ESR's that the course supports and the corresponding level of achievement:
  - P12.1 (G, U, A, M)
  - P12.2 (G, U, A, M)
  - P12.3 (G, U, A, M)
  - P12.4 (G, U, A, M)
  - P12.5 (G, U, A, M)
  - P12.6 (G, U, A, M)
- 6) Prerequisites: This course is designed for DoD military and civilian professionals who are determined to be proficient to the apprentice, journeyman or expert level (as applicable) in their current job positions in the areas of program management, systems engineering and/or test and evaluation.
- 7) Course maturity: This is a new course.
- 8) Number of contact hours and pace contemplated: This 36 hour course will provide 4 CEU's. The class will meet 3 hours per week for 12 weeks. The hour breakdown for each level of competency is provided below:
  - a) General Awareness      3 hours
  - b) Understanding          6 hours
  - c) Application              12 hours (9 hr instruction; 2 hr project, 1 hr exam)
  - d) Mastery                  15 hours (9 hr instruction; 5 hr project, 1 hr exam)
- 9) Proposed delivery modality: face-to-face.

## 10) Proposed references and texts:

- [1] Tocher K.D. (1963), *The Art of Simulation*, English Universities Press, London.
- [2] Law, A. and W. D. Kelton (2000), *Simulation Modeling and Analysis*, McGraw-Hill Book Co., New York.

## Additional useful references:

- [3] Robinson S. L. (1994), *Successful Simulation: A Practical Approach to Simulation Projects*, McGraw-Hill, Maidenhead.
- [4] Conway, R. W. and J. O. McClain (2003), "The Conduct of an Effective Simulation Study," *INFORMS Transactions on Education*, Vol. 3, No 3.  
<http://ite.pubs.informs.org/Vol3No3/ConwayMcClain/>
- [5] Swain, James J. (2001), "Power Tools for Visualization and Decision-Making," *OR/MS Today*, Vol. 28, No. 1.

## 11) Course learning objectives:

P12.1: Formulate the problem, set objectives, and conceptualize a simulation model.

P12.2: Identify and collect input data, and design sound model construct - considering simulation alternatives and required complexity.

P12.3: Include verification and validation in the overall simulation study plan. Verification refers to the process of ensuring that the model is free from logical errors - that it does what it is intended to do. Validation is the determination that the model is accurate and ensures representation of the actual system or problem.

P12.4: Estimate measures of performance for the system designs that are being simulated through use of production runs and subsequent analysis.

P12.5: Document and report on program operation, progress, decisions made and achievement of objectives.

P12.6: Create and analyze a sound simulation case study.

## 12) Course assessment plan:

1. Week 1 through week 12: Weekly quizzes to test competency at corresponding level of instruction.
2. Week 7: Class team project to demonstrate students' ability to assess and apply concepts at the application level.
3. Week 7: Mid term exam to test student competency at the application level.

4. Weeks 10-12: Class projects based on case studies to demonstrate students' ability to perform analysis and evaluation at the mastery level.
5. Week 12: Case study and final exam to test student's ability to perform analysis and evaluation at the mastery level.

13) Topic list by hour of instruction and reference:

The 36 hour course is structured such that each hour is based on its required level of competency. This structure allows the course material to be provided as four separate groupings: General Awareness, Understanding, Application, and Mastery.

General Awareness Skill Level:

- 1-3 Introduction and overview of how to develop a simulation study based on a given set of objectives. This set of objectives includes, but is not limited to: problem formulation, experiment objectives, conceptualization of the simulation model, identifying input and output data, verification and validation, measures of performance, and analysis. P12.1 – P12.6 Ref: [1], [2], instructor notes.

Understanding Skill Level:

- 4 Problem formulation, setting objectives, and conceptualizing a simulation model. P12.1 Ref: [1], [2], instructor notes.
- 5 Identification and collection of input data, and design of sound model construct – considering simulation alternatives and required complexity. P12.2 Ref: [1], [2], instructor notes.
- 6 Understanding the importance of including verification and validation in the overall simulation study plan. P12.3 Ref: [1], [2], instructor notes.
- 7-8 Determine and define system design measures of performance that are candidates for simulation. Production runs and subsequent analysis are used to illustrate this process. P12.4 Ref: [1], [2], instructor notes.
- 9 Documenting and reporting on program operation, progress, decisions made and achievement of objectives. P12.5 Ref: [1], [2], instructor notes.

Application Skill Level:

- 10 Identify and define a process that supports the development of the following: problem formulation, setting objectives, and conceptualizing a simulation model. P12.1 Ref: [1], [2], instructor notes.
- 11-12 Identify and define a process that supports the following: identification of data, collection of input data and design of sound model constructs. Consider and identify simulation alternatives based on model complexity. Use of Petri Nets, queuing models, stochastic models, Monte Carlo models and other analysis tools to be identified in this section. P12.2 Ref: [1], [2], instructor notes.

- 13-14 Identify and define a process that supports the verification and validation of the simulation plan to be tested. P12.3 Ref: [1], [2], instructor notes.
- 15-17 Identify a process that supports the development of an estimation process based on a set of performance measures to effectively test the system designs that are being simulated. The use of production runs and analysis techniques are addressed in this section. P12.4 Ref: [1], [2], instructor notes.
- 18 Identify a process that supports the development of an effective assessment plan, documenting and reporting on program operation, progress, decisions made and achievement of objectives. P12.5 Ref: [1], [2], instructor notes.
- 19-20 Class team project: Determine and apply the benefits of computer simulation based on in-class case studies. P12.6 Ref: [1], [2], instructor notes.
- 21 Mid term exam to evaluate student capability at the application level. Ref: [1], [2], instructor notes.

*Mastery Skill Level:*

- 22-23 Identify and define a process that supports analysis and evaluation of the following: problem formulation, setting objectives, conceptualizing a model and specifying operational components of the model. P12.1 Ref: [1], [2], instructor notes.
- 24-25 Identify and define a process that supports analysis and evaluation to determine a sound model design. Identify and define appropriate input, simulation alternatives and the impact of model complexity on the verification process. P12.2 Ref: [1], [2], instructor notes.
- 26-27 Identify and define a process that supports an analysis and evaluation to determine an effective verification and validation of the simulation study. P12.3 Ref: [1], [2], instructor notes.
- 28-29 Identify and define an evaluation process that determines the required number of production runs and subsequent analysis to obtain measures of performance for the system model under test. Include selected instructor case studies. P12.4 Ref: [1], [2], instructor notes.
- 30-32 Class team project: Creation of a sound simulation case study, by applying principles of previous course hours. P12.6 Ref: [1], [2], instructor notes.
- 33 Identify and define an evaluation process that supports the assessment of documenting, program operation, progress, and achievement of objectives. P12.5 Ref: [1], [2], instructor notes.
- 34-35 Class project: Identify an analysis and evaluation plan to validate the soundness of a simulation model based on instructor provided case studies. PP12.6 Ref: [1], [2], instructor notes.
- 36 Final exam to evaluate student capability at the mastery level. P12.1-P12.6 Ref: [1], [2], instructor notes.

## Old Dominion University

- 1) Course name: Abstractions and Lower levels of Realism
- 2) Course coordinator: Marsha Taliaferro-Gillis, Ph.D.  
6596 Main Street  
Gloucester, VA 23061  
(804)694-3173 (Office)  
(804)824-4663 (Cell)  
mtgillis@werneranderson.com
- 3) Course description: Selecting appropriate level of abstraction and fidelity for an operational and logistical model, learn different types of operational and logistics analyses. Understanding the role of aggregation and disaggregation across operational and logistical levels of detail and understand different levels of abstraction on verification and validation such as; scenario & threat, missions, alternatives, required input data, operations concept, basing & deployment, and support concept.
- 4) Modules incorporated into Course- O4
- 5) ESRs that the course supports and corresponding level of mastery.
  - a) Comprehension of types of operational and logistics analyses involving technical effectiveness, operational logistics, strategic logistics and tactical logistics with attention to levels of detail.  
*Competency Level: General Awareness*
  - b) Identification of the role of aggregation and disaggregation involving model aggregation in operations and logistics and develop guidelines for determining the level of model detail.  
*Competency Level: General Awareness and Understanding*
  - c) Clarification of quantifiable metrics with varying levels of abstraction and realism and selecting input probability distributions.  
*Competency Level: General Awareness and Understanding*
  - d) Identification of the difference in data requirements at different levels of abstraction, with response time, workload allocation, and supply chain management.  
*Competency Level: General Awareness and Understanding*
  - e) Demonstration of the role of modeling inputs and assumptions in developing an operational or logistics analysis with responsiveness in operations and tactical levels.  
*Competency Level: General Awareness*

- f) Using sensitivity analysis in determining solution outputs using test sequence and real-time visualization and modeling of supply chains.  
*Competency Level: General Awareness, Understanding & Application*
- g) Analysis of how differences between levels of abstraction support different phases of the acquisition cycle, to build valid, credible, and appropriately detailed simulation models.  
*Competency Level: Application and Mastery*
- h) Evaluate the impact of different levels of abstraction on verification and validation.  
*Competency Level: Mastery*
- 6) Prerequisites assumed, and corresponding level of mastery. Mastery of Introductory College Level of M&S as demonstrated by a final grade of not less than a B.
- 7) Course Maturity: none
- 8) Number of contact hours and pace contemplated: 3 hours lecture/week for 8 weeks.
- 9) Proposed Delivery modalit: face –to- face and/or online.
- 10) Module learning objectives:
  - O4.1 Describe types of operational and logistics analyses (technical effectiveness, system effectiveness, system availability, operational availability, operational reliability, response time, workload allocation, and supply chain management) and the levels of detail typically.
  - O4.2 Understand the role of aggregation and disaggregation across operational and logistical levels of detail.
  - O4.3 Understand the quantifiable metrics available at varying levels of abstraction and realism.
  - O4.4 Understand the difference in data requirements at different levels of abstraction.
  - O4.5 Describe the role of modeling inputs and assumptions in developing an operational or logistics analysis (scenario & threat, missions, alternatives, required input data, operations concept, basing & deployment, support concept, [MAIS AoA: organizational missions, functions, & objectives]).
  - O4.6 Understand the importance of sensitivity analysis of critical assumptions in determine solution outputs.
  - O4.7 Given a case study, assess how differences between levels of abstraction support different the different phases of the acquisition cycle.

O4.8 Given a case study, evaluate the impact of different levels of abstraction on verification and validation.

11) Course learning objectives: Mastery of the role of aggregation and disaggregation across operational and logistical levels of detail using quantifiable metrics available at various levels of abstraction and realism. Demonstrate differences in data requirements at different levels of abstraction. Evaluate how differences between levels of abstraction support different phases of the acquisition cycle. Analyze the impact of different levels of abstraction on verification and validation. Mastery to be demonstrated by correct responses on 90% of the questions on a final exam in a multiple choice format.

12) Course Assessment plan: final exam in a multiple choice format

13) .Topic list by hour of instruction and reference:

*Competency Level: General Awareness*

- 1) Hour one: (Sub ESR O4.1). Learn types of operational and logistics analyses (technical effectiveness, system effectiveness, system availability, operational availability, operational reliability, response time, workload allocation, and supply chain management) and learn the levels of detail. [1]

*Competency Level: General Awareness*

- 2) Hour two: (Sub ESR O4.1). Learn types of operational and logistics analyses (technical effectiveness, system effectiveness, system availability, operational availability, operational reliability, response time, workload allocation, and supply chain management) and learn the levels of detail. [1]

*Competency Level: General Awareness*

- 3) Hour three: (Sub ESR O4.2). Understand the role of aggregation and disaggregation across operational and logistical levels of detail. [1]

*Competency Level: Understanding*

- 4) Hour four: (Sub ESR O4.2). Review the role of aggregation and disaggregation across operational and logistical levels of detail. [2]

*Competency Level: Understanding*

- 5) Hour five: (Sub ESR O4.2). Review the role of aggregation and disaggregation across operational and logistical levels of detail. [2]

*Competency Level: General Awareness*

- 6) Hour six: (Sub ESR O4.3). Use the quantifiable metrics available at varying levels of abstraction and realism. [2]



*Competency Level: Understanding*

- 7) Hour seven: (Sub ESR O4.3). Use quantifiable metrics available at varying levels of abstraction and realism. [2]

*Competency Level: General Awareness*

- 8) Hour eight: (Sub ESR O4.4). Learn differences in data requirements at different levels of abstraction. [1]

*Competency Level: Understanding*

- 9) Hour nine: (Sub ESR O4.4). Demonstrate differences in data requirements at different levels of abstraction. [1]

*Competency Level: General Awareness*

- 10) Hour ten: (Sub ESR O4.5). Learn the roles of modeling inputs and assumptions in developing an operational or logistics analysis (scenario & threat, missions, alternatives, required input data, operations concept, basing & deployment, support concept, [MAIS AoA: organizational missions, functions, & objectives]). [1]

*Competency Level: General Awareness*

- 11) Hour eleven: (Sub ESR O4.5). Learn the roles of modeling inputs and assumptions in developing an operational or logistics analysis (scenario & threat, missions, alternatives, required input data, operations concept, basing & deployment, support concept, [MAIS AoA: organizational missions, functions, & objectives]). [1]

*Competency Level: General Awareness*

- 12) Hour twelve: (Sub ESR O4.6). Learn the importance of sensitivity analysis of critical assumptions in determining solution outputs. [3]

*Competency Level: Understanding*

- 13) Hour thirteen: (Sub ESR O4.6). Demonstrate the importance of sensitivity analysis of critical assumptions in determining solution outputs. [4]

*Competency Level: Understanding*

- 14) Hour fourteen: (Sub ESR O4.6). Demonstrate the importance of sensitivity analysis of critical assumptions in determining solution outputs. [3]

*Competency Level: Application*

- 15) Hour fifteen: (Sub ESR O4.6). Apply sensitivity analysis of critical assumptions to determine solution outputs. [3]

*Competency Level: Mastery*

- 16) Hour sixteen: (Sub ESR O4.7). Given a case study, analyze how differences between levels of abstraction support different phases of the acquisition cycle. [2]

*Competency Level: Mastery*

- 17) Hour seventeen: (Sub ESR O4.7). Given a case study, analyze how differences between levels of abstraction support different phases of the acquisition cycle. [2]

*Competency Level: Mastery*

- 18) Hour eighteen: (Sub ESR O4.7). Given a case study, analyze how differences between levels of abstraction support different phases of the acquisition cycle. [5]

*Competency Level: Application*

- 19) Hour nineteen: (Sub ESR O4.7). Given a case study, apply how differences between levels of abstraction support different phases of the acquisition cycle. [5]

*Competency Level: Mastery*

- 20) Hour twenty: (Sub ESR O4.7). Given a case study, analyze how differences between levels of abstraction support different phases of the acquisition cycle. [5]

*Competency Level: Mastery*

- 21) Hour twenty one: (Sub ESR O4.8). Given a case study, analyze the impact of different levels of abstraction on verification and validation. [6]

*Competency Level: Mastery*

- 22) Hour twenty two: (Sub ESR O4.8). Given a case study, analyze the impact of different levels of abstraction on verification and validation. [6]

*Competency Level: Mastery*

- 23) Hour twenty three: (Sub ESR O4.8). Given a case study, analyze the impact of different levels of abstraction on verification and validation. [6]

*Competency Level: Mastery*

- 24) Hour twenty four: (Sub ESR O4.8). Given a case study, analyze the impact of different levels of abstraction on verification and validation. [6]

14) Proposed references and texts:

- [1] Kress, J. 2002 . *Operational Logistics: The Art and Science of Sustaining Military Operations*. Kluwer Academic Publishers, Norwell, MA.

- [2] Lewis, R. O., 1992, *Independent Verification and Validation*. John Wiley & Sons, Inc, Canada.
- [3] Rubinstein, R., B. Melamed. 1998. *Modern Simulation and Modeling*. John Wiley & Sons, Inc, Canada.
- [4] Boyson, S., Harrington, L., T. M. Corsi, 2004. *In Real Time: Managing the New Supply Chain*. Praeger Publishers, Westport, CT.
- [5] Law, A. M., D. W. Kelton, 2000. *Simulation Modeling and Analysis*. The McGraw-Hill Companies, Inc., Boston, MA.
- [6] Greasley, A. 2004. *Simulation Modeling for Business*. Ashgate Publishing Limited, Burling, VT.

- 1) Course name: Analytical Models for Operational and Logistic Applications
- 2) Course coordinator: Marsha Taliaferro-Gillis, Ph.D.  
6596 Main Street  
Gloucester, VA 23061  
(804)694-3173 (Office)  
(804)824-4663 (Cell)  
mtgillis@werneranderson.com
- 3) Course description: Applications of analytical models for operations and logistic applications across the acquisition life cycle.
- 4) Modules incorporated into the Course - O1
- 5) ESRs that the course supports and corresponding level of mastery.
  - a) Acquisition cycle milestones and events supported by logistics and operational modeling applications.  
*Competency Level: General Awareness*
  - b) Use of logistics and operational models in support of concept refinement by rapid prototyping.  
*Competency Level: General Awareness and Understanding*
  - c) Use of logistics and operational models in support of system development & demonstration to support system of systems and family of systems evaluations, to focus test and evaluation, and to support transfer to production.  
*Competency Level: General Awareness and Understanding*
  - d) Use of logistics and operational models in support technology development reduces technology risks, allows the early evaluation of RM&A, transportability, and provisioning, and supports test & evaluation.  
*Competency Level: General Awareness and Understanding*
  - e) Use of logistics and operational models in support of production & deployment to streamline production and to support the development of trainers.  
*Competency Level: General Awareness and Understanding*
  - f) Use of logistics and operational models in support of operations and support to refine system design and identify future requirements.  
*Competency Level: General Awareness and Understanding*
  - g) Types of operations analyses and the levels of detail typically included in these analyses (e.g., system, engagement, mission, campaign).

*Competency Level: General Awareness*

- h) Types of logistics analyses (technical effectiveness, system effectiveness, system availability, operational availability, operational reliability, response time, work load allocation, and supply chain management) and the levels of detail typically included in these analyses.

*Competency Level: General Awareness*

- i) Role of modeling inputs and assumptions in developing a logistics and an operational analysis (scenario & threat, missions, alternatives, required input data, operations concept, basing & deployment, support concept, [MAIS AoA: organizational missions, functions, & objective]).

*Competency Level: General Awareness*

- j) Effectiveness of the M&S Support Plan in integrating M&S use throughout the life-cycle of the program through M&S reuse and the building of better models through the model-test-model.

*Competency Level: Application and Mastery*

- k) How models developed during the acquisition process can be used to support course-of-action, decision support, and training.

*Competency Level: Application and Mastery*

- 6) Prerequisites assumed, and corresponding level of mastery: Basic understanding of military operations and logistics, mastery of college level mathematical statistics.

- 7) Course maturity: none

- 8) Number of contact hours and pace contemplated: 4 hours/week for 6 weeks

- 9) Proposed Delivery modality: face-to-face, on-line or VTC

- 10) Module learning objectives:

- O1.1 Identify the acquisition cycle milestones and events supported by logistics and operational modeling applications.
- O1.2 Understand the use of logistics and operational models in support of concept refinement by rapid prototyping.
- O1.3 Understand the use of logistics and operational models in support of system development & demonstration to support system of systems and family of systems evaluations, to focus test and evaluation, and to support transfer to production.
- O1.4 Understand how the use of logistics and operational models in support technology development reduces technology risks, allows the early

evaluation of RM&A, transportability, and provisioning, and supports test & evaluation.

- O1.5 Understand the use of logistics and operational models in support of production & deployment to streamline production and to support the development of trainers.
- O1.6 Understand the use of logistics and operational models in support of operations and support to refine system design and identify future requirements.
- O1.7 Describe types of operations analyses and the levels of detail typically included in these analyses (e.g., system, engagement, mission, campaign).
- O1.8 Describe types of logistics analyses (technical effectiveness, system effectiveness, system availability, operational availability, operational reliability, response time, work load allocation, and supply chain management) and the levels of detail typically included in these analyses.
- O1.9 Describe the role of modeling inputs and assumptions in developing a logistics and an operational analysis (scenario & threat, missions, alternatives, required input data, operations concept, basing & deployment, support concept, [MAIS AoA: organizational missions, functions, & objective]).
- O1.10 Given a case study and a sample M&S Support Plan, assess the effectiveness of the M&S Support Plan in integrating M&S use throughout the life-cycle of the program through M&S reuse and the building of better models through the model-test-model.
- O1.11 Given a case study, assess how models developed during the acquisition process can be used to support course-of-action, decision support, and training.

11) Course learning objectives: Mastery of an understanding of the application of analytical models for operations and logistic applications across the acquisition life cycle including support of concept refinement, system design and development, technology development, production and deployment, and operations and support, through use of correct levels of detail, types of logistics analyses, roles of modeling inputs and assumptions, and application of the M&S Support Plan. Mastery to be demonstrated by grades of no less than B+ on all quizzes and the final project.

12) Course assessment plan: quizzes and final project.

13) Topic list by hour of instruction and reference.

*Competency Level: General Awareness*

- 1) Hour 1: (Sub ESR O1.1). Learn the acquisition cycle milestones and events supported by logistics and operational modeling applications. [1] [2] [3]

*Competency Level: General Awareness*

- 2) Hour 2: (Sub ESR O1.2). Demonstrate the use of logistics and operational models in support of concept refinement by rapid prototyping. [2] [4]

*Competency Level: Understanding*

- 3) Hour 3: (Sub ESR O1.2). Demonstrate the use of logistics and operational models in support of concept refinement by rapid prototyping. [2] [4]

*Competency Level: General Awareness*

- 4) Hour 4: (Sub ESR O1.3). Learn the use of logistics and operational models in support of system development & demonstration to support system of systems and family of systems evaluations, to focus test and evaluation, and to support transfer to production. [2] [4]

*Competency Level: Understanding*

- 5) Hour 5: (Sub ESR O1.3). Review the use of logistics and operational models in support of system development & demonstration to support system of systems and family of systems evaluations, to focus test and evaluation, and to support transfer to production. [2] [4]

*Competency Level: General Awareness*

- 6) Hour 6: (Sub ESR O1.4). Learn how the use of logistics and operational models in support technology development reduces technology risk, allows the early evaluation of RM&A, transportability, and provisioning, and supports test & evaluation. [2] [4]

*Competency Level: Understanding*

- 7) Hour 7: (Sub ESR O1.4). Understand how the use of logistics and operational models in support technology development reduces technology risk, allows the early evaluation of RM&A, transportability, and provisioning, and supports test & evaluation. [2] [4]

*Competency Level: General Awareness*

- 8) Hour 8: (Sub ESR O1.5). Learn the use of logistics and operational models in support of production & deployment to streamline production and to support the development of trainers. [2] [4]

*Competency Level: Understanding*

- 9) Hour 9: (Sub ESR O1.5). Understand the use of logistics and operational models in support of production & deployment to streamline production and to support the development of trainers. [2] [4]

*Competency Level: General Awareness*

- 10) Hour 10: (Sub ESR O1.6). Learn the use of logistics and operational models in support of operations and support to refine system design and identify future requirements. [5]

*Competency Level: Understanding*

- 11) Hour 11: (Sub ESR O1.6). Understand the use of logistics and operational models in support of operations and support to refine system design and identify future requirements. [5]

*Competency Level: General Awareness*

- 12) Hour 12: (Sub ESR O1.7). Describe types of operations analyses and the levels of detail typically included in these analyses (e.g., system, engagement, mission, campaign). [5]

*Competency Level: General Awareness*

- 13) Hour 13: (Sub ESR O1.7). Review types of operations analyses and the levels of detail typically included in these analyses (e.g., system, engagement, mission, campaign). [5]

*Competency Level: General Awareness*

- 14) Hour 14: (Sub ESR O1.7). Review types of operations analyses and the levels of detail typically included in these analyses (e.g., system, engagement, mission, campaign). [5]

*Competency Level: General Awareness*

- 15) Hour 15: (Sub ESR O1.8). Study types of logistics analyses (technical effectiveness, system effectiveness, system availability, operational availability, operational reliability, response time, workload allocation, and supply chain management) and the levels of detail typically included in these analyses. [5]

*Competency Level: General Awareness*

- 16) Hour 16: (Sub ESR O1.8). Describe types of logistics analyses (technical effectiveness, system effectiveness, system availability, operational availability, operational reliability, response time, workload allocation, and supply chain management) and the levels of detail typically included in these analyses. [5]

*Competency Level: General Awareness*

- 17) Hour 17: (Sub ESR O1.8). Describe types of logistics analyses (technical effectiveness, system effectiveness, system availability, operational availability, operational reliability, response time, workload allocation, and supply chain management) and the levels of detail typically included in these analyses. [5]



*Competency Level: General Awareness*

- 18) Hour 18: (Sub ESR O1.9). Understand the role of modeling inputs and assumptions in developing a logistics and an operational analysis (scenario & threat, missions, alternatives, required input data, operations concept, basing & deployment, support concept, [MAIS AoA: organizational missions, functions, & objective]). [6]

*Competency Level: General Awareness*

- 19) Hour 19: (Sub ESR O1.9). Describe the role of modeling inputs and assumptions in developing a logistics and an operational analysis (scenario & threat, missions, alternatives, required input data, operations concept, basing & deployment, support concept, [MAIS AoA: organizational missions, functions, & objective]). [6]

*Competency Level: Application*

- 20) Hour 20: (Sub ESR O1.10). Given a case study and a sample M&S Support Plan, assess the effectiveness of the M&S Support Plan in integrating M&S use throughout the lifecycle of the program through M&S reuse and the building of better models through the model-test-model approach. [6]

*Competency Level: Mastery*

- 21) Hour 21: (Sub ESR O1.10). Given a case study and a sample M&S Support Plan, assess the effectiveness of the M&S Support Plan in integrating M&S use throughout the lifecycle of the program through M&S reuse and the building of better models through the model-test-model approach. [6]

*Competency Level: Mastery*

- 22) Hour 22: (Sub ESR O1.10). Given a case study and a sample M&S Support Plan, assess the effectiveness of the M&S Support Plan in integrating M&S use throughout the lifecycle of the program through M&S reuse and the building of better models through the model-test-model approach. [6]

*Competency Level: Application*

- 23) Hour 23: (Sub ESR O1.11). Given a case study, assess how models developed during the acquisition process can be used to support course-of-action, decision support, and training. [6]

*Competency Level: Mastery*

- 24) Hour 24: (Sub ESR O1.11). Given a case study, assess how models developed during the acquisition process can be used to support course-of-action, decision support, and training. [6]

14) Proposed references and texts:

- [1] DoD 5000.1. Documents. Processes & Mehtods. Retrieved November 24, 2007, <https://acc.dau.mil/CommunityBrowser.aspx?id=37340&lnag=en-US> – 38k
- [2] DoD 5000.2. Documents. Processes & Mehtods. Retrieved November 24, 2007, <https://acc.dau.mil/CommunityBrowser.aspx?id=37340&lnag=en-US> – 38k
- [3] CJCSI 3170.01“Joint Capabilites Integration and Development System. Retrieved November 24, 2007, [www.army.thewayahead/acpdownloads/3170-01.pdf](http://www.army.thewayahead/acpdownloads/3170-01.pdf)-
- [4] Defense Acquisition Guidebook. Retrieved November 24, 2007. <https://akss.dau.mil/dag/DoD5000.asp?view=document> – 2k -
- [5] Kress, Moshe. 2002. *Operational Logistics: The Art and Science of Sustaining Military Operations*. Massachusetts: Kluwer Academic Publishers.
- [6] DoD 5000.59. “DoD Modeling and simulation (M&S) Managenebt, Retrieved November 24, 1007, <https://www.dmsomil/public/library/policy/guidance/500059p.pdf> -
- [7] *Test & Evaluation Management Guide, Chaps 20&14..* Retrieved Mpve,ber 24, 2007, [www.dau.mil/pubss/gdbks/test\\_eval\\_guide.asp](http://www.dau.mil/pubss/gdbks/test_eval_guide.asp) - 12k
- [8] VV&A Recommended Practices Guide. Retrieved November 24, 2007, [wa.dmsomil/Ref\\_Docs/VVTechnical/wtechniques.htm](http://wa.dmsomil/Ref_Docs/VVTechnical/wtechniques.htm) – 592k

- 1) Course name: Appropriate Statistical Technique
- 2) Course coordinator: Marsha Taliaferro-Gillis, Ph.D.  
6596 Main Street  
Gloucester, VA 23061  
(804)694-3173 (Office)  
(804)824-4663 (Cell)  
mtgillis@werneranderson.com
- 3) Course description: Appropriate statistical techniques for the analysis of simulation output.
- 4) Modules incorporated into Course - P13
- 5) ESRs that the course supports and corresponding levels of mastery.
  - a) Transient and steady state behaviors of stochastic processes.  
Competency Level: General Awareness and Understanding
  - b) Statistical analysis for terminating simulations  
Competency Level: General Awareness, Understanding, and Application
  - c) Statistical Analysis for steady state parameters.  
Competency Level: General Awareness, Understanding, and Application
  - d) Statistical analysis for steady state cycle parameters.  
Competency Level: General Awareness, Understanding, and Application
  - e) Methods for evaluating multiple measures of performance  
Competency Level: General Awareness, Understanding, and Application
  - f) Methods for plotting and analyzing data.  
Competency Level: General Awareness, Understanding, and Application
  - g) Hypothesis testing, ANOVA, confidence intervals.  
Competency Level: General Awareness, Understanding, and Application
  - h) Methods for comparing multiple alternatives – ranking and selection.  
Competency Level: General Awareness, Understanding, and Application.
  - i) Generation of random variable in computers and variance reduction.  
Competency Level: General Awareness, Understanding, and Application
  - j) Experimental design, optimization, and sensitivity analysis.  
Competency Level: General Awareness, Understanding, and Mastery

- 6) Prerequisites assumed and corresponding level of mastery: Probability, Statistics, and Calculus II at a mastery level as demonstrated by a final course grade of not less than a B for all courses.
- 7) Course maturity: none
- 8) Number of contact hours and pace contemplated: 4 lecture hours/week for 9 weeks.
- 9) Proposed Delivery modality: face-to-face, and/or on-line
- 10) Module learning objectives:
  - P13.1 Understand transient and steady-state behavior of stochastic processes
  - P13.2 Apply statistical analysis for terminating simulations
  - P13.3 Apply statistical analysis for steady state parameters
  - P13.4 Apply statistical analysis for steady-state cycle parameters
  - P13.5 Apply methods for evaluating multiple measures of performance
  - P13.6 Apply plotting methods for analyzing data
  - P13.7 Apply hypothesis testing, ANOVA, and confidence intervals
  - P13.8 Apply methods for comparing multiple alternatives (e.g. ranking and selection)
  - P13.9 Understand the generation of random variates in computers and apply variance reduction techniques
  - P13.10 Understand experimental design and optimization and apply sensitivity analysis
- 11) Course Learning Objectives: Mastery of the appropriate statistical techniques for understanding transient and steady state behavior of stochastic processes; applying statistical analysis for terminating simulations; analyzing steady state, and cycle parameters; evaluating multiple measures of performance; plotting and analyzing data, applying hypothesis testing, confidence interval, and ANOVA; comparing multiple alternatives; generating of random variates in computers; applying variance reduction; and experimental design, optimization and sensitivity analysis. Mastery is to be demonstrated by a grade of 85% correct on all quizzes and the final exam.
- 12) Course assessment plan: bi-weekly quizzes and final exam in a multiple choice format of 100 questions.
- 13) Topic list by hour of instruction and reference.

*Competency Level: General Awareness*

- 1) Hour 1: (Sub ESR P13.1). Define transient and steady-state behavior of stochastic processes. [1] [2]

*Competency Level: Understanding*

- 2) Hour 2: (Sub ESR P13.1). Explain transient and steady-state behavior of stochastic processes. [1] [2]

*Competency Level: Understanding*

- 3) Hour 3: (Sub ESR P13.1). Give an example of transient and steady-state behavior of stochastic processes. [1] [2]

*Competency Level: Understanding*

- 4) Hour 4: (Sub ESR P13.1). Summarize transient and steady-state behavior of stochastic processes. [1] [2]

*Competency Level: General Awareness*

- 5) Hour 5: (Sub ESR P13.2). Describe statistical analysis for terminating simulations. [1]

*Competency Level: Understanding*

- 6) Hour 6: (Sub ESR P13.2). Give examples of statistical analysis for terminating simulations. [1]

*Competency Level: Application*

- 7) Hour 7: (Sub ESR P13.2). Demonstrate statistical analysis for terminating simulations. [1]

*Competency Level: Application*

- 8) Hour 8: (Sub ESR P13.2). Apply statistical analysis for terminating simulations. [1]

*Competency Level: General Awareness*

- 9) Hour 9: (Sub ESR P13.3). Define statistical analysis for steady-state parameters. [1]

*Competency Level: Understanding*

- 10) Hour 10: (Sub ESR P13.3). Produce a statistical analysis for a steady state parameters. [1]

*Competency Level: Application*

- 11) Hour 11: (Sub ESR P13.3). Explain statistical analysis for steady state parameters. [1]

*Competency Level: Application*

- 12) Hour 12: (Sub ESR P13.3). Produce a statistical analysis for a steady state parameters. [1]

*Competency Level: General Understanding*

- 13) Hour 13: (Sub ESR P13.4). Demonstrate statistical analyses for steady-state cycle parameters. [1]

*Competency Level: Understanding*

- 14) Hour 14: (Sub ESR P13.4). Explain statistical analysis for steady-state cycle parameters. [1]

*Competency Level: Application*

- 15) Hour 15: (Sub ESR P13.4). Apply statistical analysis for steady-state cycle parameter. [1]

*Competency Level: Application*

- 16) Hour 16: (Sub ESR P13.4). Apply statistical analysis for steady-state cycle parameters. [1]

*Competency Level: General Awareness*

- 17) Hour 17: (Sub ESR P13.5). Apply methods for evaluating multiple measures of performance. [3]

*Competency Level: Understanding*

- 18) Hour 18: (Sub ESR P13.5). Apply methods for evaluating multiple measures of performance. [3]

*Competency Level: Application*

- 19) Hour 19: (Sub ESR P13.5). Prepare methods for evaluating multiple measures of performance. [3]

*Competency Level: Application*

- 20) Hour 20: (Sub ESR P13.6). Produce plotting methods for analyzing data. [4]

*Competency Level: Application*

- 21) Hour 21: (Sub ESR P13.6). Apply plotting methods for analyzing data. [4]

*Competency Level: General Awareness*

- 22) Hour 22: (Sub ESR P13.7). Describe hypothesis testing, ANOVA, and confidence intervals. [1] [4] [5] [6]

*Competency Level: Understanding*

- 23) Hour 23: (Sub ESR P13.7). Summarize hypothesis testing, ANOVA, and confidence intervals. [1] [4] [5] [6]

*Competency Level: Application*

- 24) Hour 24: (Sub ESR P13.7). Apply hypothesis testing, ANOVA, and confidence intervals. [1] [4] [5] [6]

*Competency Level: Application*

- 25) Hour 25: (Sub ESR P13.7). Apply hypothesis testing, ANOVA, and confidence intervals. [1] [4] [5] [6]

*Competency Level: Application*

26) Hour 26: (Sub ESR P13.7). Apply hypothesis testing, ANOVA, and confidence intervals. [1] [4] [5] [6]

*Competency Level: General Awareness*

27) Hour 27: (Sub ESR P13.8). Recognize methods for comparing multiple alternatives (e.g. ranking and selection). [1]

*Competency Level: Understanding*

28) Hour 28: (Sub ESR P13.8). Explain methods for comparing multiple alternatives (e.g. ranking and selection). [1]

*Competency Level: Application*

29) Hour 29: (Sub ESR P13.8). Apply methods for comparing multiple alternatives (e.g. ranking and selection). [1]

*Competency Level: General Awareness*

30) Hour 30: (Sub ESR P13.9). Understand the generation of random variates in computers and apply variance reduction techniques. [1] [2]

*Competency Level: Understanding*

31) Hour 31: (Sub ESR P13.9). Understand the generation of random variates in computers and apply variance reduction techniques. [1] [2]

*Competency Level: Understanding*

32) Hour 32 (Sub ESR P13.9). Understand the generation of random variates in computers and apply variance reduction techniques. [1] [2]

*Competency Level: Application*

33) Hour 33: (Sub ESR P13.9). Predict the generation of random variates in computers and apply variance reduction techniques. [1] [2]

*Competency Level: General Awareness*

34) Hour 34: (Sub ESR P13.10). Understand experimental design and optimization and apply sensitivity analysis. [1] [2]

*Competency Level: Understanding*

35) Hour 35: (Sub ESR P13.10). Understand experimental design and optimization and apply sensitivity analysis. [1] [2]

*Competency Level: Understanding*

36) Hour 36: (Sub ESR P13.10). Understand experimental design and optimization and apply sensitivity analysis. [1] [2]

14) Proposed references and texts:

[1] Averill, M. Law, W. David, Kelton. 2000. *Simulation Modeling and Analysis*. The McGraw Hill Companies, Boston.

- [2] Rubenstein, Reuven Y., Benjamin, Melamel. 1998. *Modern Simulation and Modeling*. John Wiley & Sons, Inc., 605 Third Avenue, New York, NY.
- [3] Johnson, J.A., D.W., Wichern. 1992. *Applied Multivariate Statistical Analysis*, Prentice-Hall, Inc., Upper Saddle River, NJ, USA
- [4] Box, George E.P., William G., Hunter, J. Stuart, Hunter. 1978. *Statistics for Experimenters; An Introduction to Design, Data Analysis, and Model Building*, John Wiley & Sons, New York.
- [5] Guttman, Irwin, S, S, Wilks, J. Stuart, Hunter. 1982. *Introductory Engineering Statistics*. John Wiley & Sons, Inc., Canada.
- [6] Sargeant, Robert G. 1976. Statistical Analysis of Simulation Output: Data Simulation of Computer Networks, Proceedings of the 4<sup>th</sup> Symposium on Simulation of Computer Systems, Boulder, Colorado. ACM Special Interest Group on Simulation and Modeling. The ACM Digital Library, IEEE Press, Piscataway, NJ, USA.



- 1) Course Name: Best Practices In Modeling and Simulation
- 2) Course coordinator: Marsha Taliaferro-Gillis, Ph.D.  
6596 Main Street  
Gloucester, VA 23061  
(804)694-3173 (Office)  
(804)824-4663 (Cell)  
mtgillis@werneranderson.com
- 3) Course description: Review of the best practices and standards in modeling and simulation. Requirements for development of best practices and standards. in modeling and simulation. Application of requirements to key case studies. VV&A reporting. Development and acquisition in M&S lifecycle.
- 4) Modules incorporated into Course - P8
- 5) ESRs that the course supports and corresponding level of mastery.
  - a) Best Practices in M&S Planning  
*Competency Level: General Awareness*
  - b) Best practices in M&S tool development (requirements, conceptual modeling)  
*Competency Level: General Awareness and Understanding*
  - c) Best practices in M&S federation development (DIS, HLA, IEEE standards)  
*Competency Level: General Awareness*
  - d) Best practices in software development as it applies to M&S (IEEE standards, configuration management, maturity model standards)  
*Competency Level: General Awareness and Understanding*
  - e) Best practices in VV&A (maturity model, IEEE standards)  
*Competency Level: General Awareness, Understanding, and Application*
  - f) Application of a sample M&S Support Plan to provide best use of M&S across all stages of the acquisition lifecycle  
*Competency Level: General Awareness and Application*
  - g) Analysis of a sample V&V report for inclusion in best practices in VV&A.  
*Competency Level: General Awareness and Mastery*
  - h) Analysis of the benefit of M&S best practices across all components of the M&S development lifecycle  
*Competency Level: General Awareness and Mastery*

- i) Analysis of the benefit of M&S best practices across all components of the acquisition life-cycle.

*Competency Level: General Awareness and Mastery*

- 6) Prerequisites assumed, and corresponding level of mastery. Mastery of College Level Calculus II and Introduction to M&S as demonstrated by a final grade of not less than a B.
- 7) Course maturity: none
- 8) Number of contact hours and pace contemplated: 3 hours lecture/week for 8 weeks.
- 9) Proposed Delivery modality: face-to-face and/or on line.
- 10) Module learning objectives:

- P8.1 Identify best practices in M&S planning
- P8.2 Identify best practices in M&S tool development (requirements, conceptual modeling)
- P8.3 Identify best practices in M&S federation development (DIS, HLA, IEEE standards)
- P8.4 Identify best practices in software development as it applies to M&S (IEEE standards, configuration management, maturity model standards)
- P8.5 Identify best practices in VV&A (maturity model, IEEE standards)
- P8.6 Apply a sample M&S Support Plan to provide best use of M&S across all stages of the acquisition lifecycle.
- P8.7 Analyze a sample V&V report for inclusion of best practices in VV&A.
- P8.8 Given a case study, analyze the benefit of M&S best practices across all components of the M&S development lifecycle.
- P8.9 Given a case study, analyze the benefit of M&S best practices across all components of the acquisition life-cycle.

- 11) Course learning objectives: Mastery of best practices in applying federation standards, tool development, conceptual modeling, configuration management, support planning, and V&V reporting, across all components of M&S acquisition life cycle. Mastery is to be demonstrated by a grade of 85% correct on ;the final examination of 100 multiple choice questions.

- 12) Course assessment plan: final exam in a multiple choice format.

- 13) Topic list by hour of instruction and reference:

*Competency Level: General Awareness*

- 1) Hour 1: (Sub ESR P8.1). Review best practices in M&S planning. [1]  
[2]

*Competency Level: General Awareness*

- 2) Hour 2: (Sub ESR P8.2). Learn conceptual modeling and best practices in M&S tool development. [3]

*Competency Level: General awareness*

- 3) Hour 3: (Sub ESR P8.2). Learn conceptual modeling and best practices in M&S tool development.. [3]

*Competency Level: Understanding*

- 4) Hour 4: (Sub ESR P8.2). Use conceptual modeling and best practices in developing M&S tools. [3]

*Competency Level: General Awareness*

- 5) Hour 5: (Sub ESR P8.3). Learn the mechanics of developing federation standards (DIS, HLA, IEEE) for the best practices in M&S. [4] [5] [6] [7]

*Competency Level: General Awareness*

- 6) Hour 6: (Sub ESR P8.4). Learn IEEE standards, maturity model standards, configuration management, and best practices for M&S software development.. [8] [7]

*Competency Level: General awareness*

- 7) Hour 7: (Sub ESR P8.4). Learn IEEE standards, maturity model standards, configuration management, and best practices for M&S software development. [8] [7]

*Competency Level: General Awareness*

- 8) Hour 8: (Sub ESR P8.5). Learn IEEE standards and maturity models for best practices in VV&A. [9] [10]

*Competency Level: General awareness*

- 9) Hour 9: (Sub ESR P8.5). Learn IEEE standards and maturity models for best practices in VV&A. [9] [10]

*Competency Level: Understanding*

- 10) Hour 10: (Sub ESR P8.5). Demonstrate best practices in using IEEE standards and maturity models for VV&A. [9] [10]

*Competency Level: Application*

- 11) Hour 11: (Sub ESR P8.5). Apply best practices in using IEEE standards and maturity models for VV&A. [9] [10]

*Competency Level: General Awareness*

- 12) Hour 12: (Sub ESR P8.6). Learn Support Planning across all stages of M&S acquisition lifecycle. [1] [2]

*Competency Level: Application*

- 13) Hour 13: (Sub ESR P8.6). Apply Support Planning across a sample of all stages of M&S acquisition lifecycle. [1] [2]

*Competency Level...Application*

- 14) Hour 14: (Sub ESR P8.6). Apply Support Planning across all stages of M&S acquisition lifecycle. [1] [2]

*Competency Level: General Awareness*

- 15) Hour 15: (Sub ESR P8.7). Learn the components and best practices of VV&A reporting. [9] [10]

*Competency Level: Application*

- xvi) Hour 16: (Sub ESR P8.7). Apply best practices to a sample VV&A report. [9] [10]

*Competency Level: Mastery*

- xvii) Hour 17: (Sub ESR P8.7). Analyze a sample V&V report for inclusion of best practices in VV&A. [9] [10]

*Competency Level: General Awareness*

- xviii) Hour 18: (Sub ESR P8.8). Learn the benefits best practice analysis across all components of the M&S development lifecycle. [11] [12] [13] [14]

*Competency Level: General Awareness*

- xix) Hour 19: (Sub ESR P8.8). Learn the benefits of best practice analysis across all components of the M&S development lifecycle. [11] [12] [13] [14]

*Competency Level: Understanding*

- xx) Hour 20: (Sub ESR P8.8). Use a best practice analysis across all components of a sample M&S development lifecycle. [11] [12] [13] [14]

*Competency Level: Application*

- xxi) Hour 21: (Sub ESR P8.8). Apply a best practice analysis across all components of a sample M&S development lifecycle. [11] [12] [13] [14]

*Competency Level: Mastery*

- xxii) Hour 22: (Sub ESR P8.9). Given a case study, analyze the benefit of M&S best practices across all components of the acquisition lifecycle. [11] [12] [13] [14]

*Competency Level: Mastery*

- xxiii) Hour 23: (Sub ESR P8.9). Given a case study analyze the benefits of M&S best practices across all components of the acquisition life cycle. [11] [12] [13] [14]

*Competency Level: Mastery*

- xxiv) Hour 24: (Sub ESR P8.9). Given a case study analyze the benefits of M&S best practices across all components of the acquisition life cycle. [11] [12] [13] [14]

14) Proposed references and texts:

- [1] Ledin, Jim. 2001. *Simulation Engineering: Build Better Embedded systems Faster*, C M P Books, ISBN-13 9781578200801.
- [2] Bucknell University, Modeling and Simulation Best Practices for Wireless Ad Hoc. Retrieved October 24, 2007.  
<http://whitepapers.techrepublic.com.com/whitepaper.aspx?docid=161862>
- [3] Schrage, Michael D. 1999. *Serious Play: How the World's Best Companies Simulate to Innovate*. 1999. Harvard Business School Press, Boston. ISBN 13: 9780875848143
- [4] Distributed Interactive Simulation. Doi.ieeecs.org. Retrieved October 24, 2007.  
<http://scholar.google.com/scholar?Q=author:%22Davis%22+intitle:%22A+strategy+for+c...>
- [5] High Level Architecture. Retrieved October 24, 2007.  
[http://en.wikipedia.org/wiki/High\\_Level\\_Architecture](http://en.wikipedia.org/wiki/High_Level_Architecture)
- [6] SISC Meeting 3-17-1999. [www.sisostds.org/index.php?Tg=fileman&idx=get&id=Y&path=&file=SISC\\_99\\_03\\_17\\_rev](http://www.sisostds.org/index.php?Tg=fileman&idx=get&id=Y&path=&file=SISC_99_03_17_rev). Retrieved October 24, 2007. <http://www.google.com/search?hl=en&q=HLA+Standards&btnG+Search>
- [7] IEEE LTSC WG12 Standard for Information Technology – Education and Training Systems – Learning Objects and Metadata. Itsc.ieee.org/wg12/
- [8] Law, Averill M. 2006. *Simulation Modeling and Analysis with Expertfit Software*, The McGraw-Hill Companies, Boston.
- [9] Pace, Dale K. 2004. Modeling and Simulation Verification and Validation Challenges. *Johns Hopkins APL Technical Digest*. 25(2).
- [10] Richey, Frank, 2002. Modeling and Simulation CMMI: A Conceptual View. *Cross Talk-The Journal of Defense Software Engineering*. Retrieved October 24, 2007. <http://www.stsc.hill.af.mil/crosswalk/2002/03/richey.html>

[11] Murray, K. J., S.V.Sheppard. 1988. Knowledge-based simulation model specification. *Simulation*, 1988. Sim.sagepub.com. Bell Communications Research, 444 Hoes lane – RRC Piscataway, New Jersey 08854.

[12] Christie, Alan M. 1999. Simulation: An Enabling Technology in Software Engineering. *Cross Talk-The Journal of Defense Software Engineering* Sei.cmu.edu. Retrieved October 24, 2007.  
<http://scholar.google.com/scholar?author=%22Christie%22+intitle:%22Simulation%22+An...>

[13] Davis, Alan M., Bersoff, Edward H., Comer, E. R. 1988. A strategy for comparing alternative software development life cycle models. Retrieved October 24, 2007.  
<http://scholar.google.com/scholar?q=%22Davis%22+intitle:%22A+strategy+for+c...>

[14] Bevan, Michelle T. 2001. Modeling and Simulation for Acquisition, Requirements and Training: The Army SMART Model. *The National Summit on U.S. Defense Policy: Acquisition, Research, Test and Evaluation*. IIT – Research Institute. Msic Retrieved October 24 2007.

- 1) Course Name: C4ISR/Sim TRM
- 2) Course coordinator: Marsha Taliaferro-Gillis, Ph.D.  
6596 Main Street  
Gloucester, VA 23061  
(804)694-3173 (Office)  
(804)824-4663 (Cell)  
mtgillis@werneranderson.com
- 3) Course description: Describe the basic components, methods and alternatives for transferring information from one point to another both internal and external to the system being considered through the means of C4ISR systems. Evaluate available technologies for achieving rapid/effective/jam-resistant information transfer.
- 4) Modules incorporated into Course - E10
- 5) ESRs that the course supports and corresponding level of mastery.
  - a) Key fundamental theoretical principles in systems engineering  
*Competency Level: General Awareness*
  - b) Role and benefits of M&S in systems engineering  
*Competency Level: General Awareness and Understanding*
  - c) Key system characteristics of the system and component subsystems of interest  
*Competency Level: General Awareness and Understanding*
  - d) Key elements of the system and component subsystem to be modeled to meet the requirements of the specific use  
*Competency Level: Application and Mastery*
  - e) Effectiveness of simulation tools used to evaluate the performance of the system and components subsystems  
*Competency Level: Application and Mastery*
  - f) Role of component-based and distributed simulation as it applies to the system and component subsystems  
*Competency Level: Application and Mastery*
  - g) M&S issues related to interaction of subsystems within a larger system  
*Competency Level: Application*

- h) VV&A implication of using a simulation of a system that is sufficiently different from its intended use  
*Competency Level: Understanding and Mastery*
- i) Level of model detail for system and component subsystems to support program milestone decision requirements  
*Competency Level: Understanding and Mastery*
- j) Level of model detail for system and component subsystems to support T&E requirements  
*Competency Level: Understanding and Mastery*
- 6) Prerequisites assumed, and corresponding level of mastery: Understanding of military C4ISR systems and their application.
- 7) Course maturity: none
- 8) Number of contact hours and pace contemplated: 3 hours lecture/week for 8 weeks.
- 9) Proposed Delivery modality: face-to-face or on-line
- 10) Module learning objectives:
  - E10.1 Identify key fundamental theoretical principles in C4ISR systems engineering
  - E10.2 Describe the role and benefits of M&S in C4ISR systems engineering
  - E10.3 Given a case study, understand key system characteristics of the C4ISR system of interest
  - E10.4 Given a case study, identify the key elements of the C4ISR system to be modeled to meet the requirements of the specific use
  - E10.5 Given a case study, apply or analyze the effectiveness of simulation tools used to evaluate the performance of the C4ISR system
  - E10.6 Given a case study, apply or analyze key M&S issues related to interaction of subsystems within the C4ISR systems
  - E10.7 Given a case study, analyze the VV&A implications of using a simulation of a C4ISR system given that is sufficiently different from its intended use
  - E10.8 Given a case study, analyze whether the C4ISR system is modeled in sufficient detail to support program milestone decision requirements
  - E10.9 Given a case study, analyze whether the C4ISR system is modeled in sufficient detail to support T&E requirements
- 11) Course learning objectives: Mastery of C4ISR systems engineering concepts as related to M&S, including identifying key elements of a C4ISR system to be modeled, determining effectiveness of M&S tools for C4ISR applications, modeling C4ISR subsystems, implications of VV&A, and using M&S to support



program milestone decision requirements and T&E. Mastery to be demonstrated by a final grade of not less than B+ on quizzes and final project.

12) Course assessment plan: quizzes and final project.

13) Topic list by hour of instruction and reference:

*Competency Level: General Awareness*

- 1) Hour 1: (Sub ESR E10.1). Learn key fundamental theoretical principles in C4ISR systems engineering. [1] [2]

*Competency Level: General Awareness*

- 2) Hour 2: (Sub ESR E10.1). Learn key fundamental theoretical principles in C4ISR systems engineering. [1] [2]

*Competency Level: General Awareness*

- 3) Hour 3: (Sub ESR E10.2). Learn the role and benefits of M&S in C4ISR systems engineering. [3] [4]

*Competency Level: Understanding*

- 4) Hour 4: (Sub ESR E10.2). Review the role and benefits of M&S in C4ISR systems engineering. [3] [4]

*Competency Level: General Awareness*

- 5) Hour 5: (Sub ESR E10.3). Given a case study, understand key system characteristics of the C4ISR system of interest. [3] [4]

*Competency Level: General Awareness*

- 6) Hour 6: (Sub ESR E10.3). Given a case study, understand key system characteristics of the C4ISR system of interest. [3] [4]

*Competency Level: Understanding*

- 7) Hour 7: (Sub ESR E10.3). Given a case study, identify key system characteristics of the C4ISR system of interest. [3] [4]

*Competency Level: Application*

- 8) Hour 8: (Sub ESR E10.4). Given a case study, identify the key elements of the C4ISR system to be modeled to meet the requirements of the specific use. [3] [4]

*Competency Level: Application*

- 9) Hour 9: (Sub ESR E10.4). Given a case study, identify the key elements of the C4ISR system to be modeled to meet the requirements of the specific use. [3] [4]

*Competency Level: Mastery*

- 10) Hour 10: (Sub ESR E10.4). Given a case study, analyze the key elements of the C4ISR system to be modeled to meet the requirements of the specific use. [3] [4]

*Competency Level: Application*

- 11) Hour 11: (Sub ESR E10.5). Given a case study, apply and analyze the effectiveness of simulation tools used to evaluate the performance of the C4ISR system. [5]

*Competency Level: Application*

- 12) Hour 12: (Sub ESR E10.5). Given a case study, apply and analyze the effectiveness of simulation tools used to evaluate the performance of the C4ISR system. [5]

*Competency Level: Mastery*

- 13) Hour 13: (Sub ESR E10.5). Given a case study, apply the effectiveness of simulation tools used to evaluate the performance of the C4ISR system. [5]

*Competency Level: Application*

- 14) Hour 14 (Sub ESR E10.6). Given a case study, apply or analyze key M&S issues related to interaction of subsystems within the C4ISR systems. [2]

*Competency Level: Application*

- 15) Hour 15: (Sub ESR E10.6). Given a case study, apply or analyze key M&S issues related to interaction of subsystems within the C4ISR systems. [2]

*Competency Level: Understanding*

- 16) Hour 16: (Sub ESR E10.7). Given a case study, analyze the VV&A implications of using a simulation of a C4ISR system given that is sufficiently different from its intended use. [6]

*Competency Level: Application*

- 17) Hour 17: (Sub ESR E10.7). Given a case study, analyze the VV&A implications of using a simulation of a C4ISR system given that is sufficiently different from its intended use. [6]

*Competency Level: Mastery*

- 18) Hour 18: (Sub ESR E10.7). Given a case study, analyze the VV&A implications of using a simulation of a C4ISR system given that is sufficiently different from its intended use. [6]

*Competency Level: Understanding*

- 19) Hour 19: (Sub ESR E10. 8). Given a case study, analyze whether the C4ISR system is modeled in sufficient detail to support program milestone decision requirements CJCSI 3170.01. [7]

*Competency Level: Mastery*

- 20) Hour 20: (Sub ESR E10.8). Given a case study, analyze whether the C4ISR system is modeled in sufficient detail to support program milestone decision requirements. [7] [8]

*Competency Level: Mastery*

- 21) Hour 21: (Sub ESR E10.8). Given a case study, analyze whether the C4ISR system is modeled in sufficient detail to support program milestone decision requirements [7] [8]

*Competency Level: Understanding*

- 22) Hour 22: (Sub ESR E10.9). Given a case study, analyze whether the C4ISR system is modeled in sufficient detail to support T&E requirements. [9]

*Competency Level: Mastery*

- 23) Hour 23: (Sub ESR E10.9). Given a case study, analyze whether the C4ISR system is modeled in sufficient detail to support T&E requirements. [9]

*Competency Level: Mastery*

- 24) Hour 24: (Sub ESR E10.9). Given a case study, analyze whether the C4ISR system is modeled in sufficient detail to support T&E requirements. [9]

14) Proposed references and texts:

[1] Kossiakoff, Alexander; William N. Sweet. 2003 *Systems Engineering Principles and Practice*. Hoboken, NJ. John Wiley & Sons. Boston

[2] Daly, John J., Andreas Tolk. *Modeling and Simulation Integration with Network-Centric Command and Control Architectures*. 2003 Fall Simulation Interoperability Workshop. <http://bacon.gmu.edu/XMSF/pubs/03F-SIW-121.pdf>

[3] Davis, Paul K. *Effects of Terrain, Maneuver Tactics, and C4ISR on the Effectiveness of Long-Range Precision Fires: A Stochastic Multiresolution Model (PEM) Calibrated to High-Resolution Simulation*. Santa Monica, CA: RAND, 2000.

[4] Pace, Dale K. *Conceptual Model Development for C4ISR Simulations*, The Johns Hopkins University Applied Physics Laboratory. Retrieved October 29, 2007, [http://www.dodccrp.org/events/5th\\_ICCRTS/papers/Track2/059.pdf](http://www.dodccrp.org/events/5th_ICCRTS/papers/Track2/059.pdf)

- [5] Gonzales, Daniel, Louis R. Moore, Christopher G. Pernin, David M. Matonick, Paul Dreyer. *Assessing the Value of Information Superiority for Ground Forces-Proof of Concept*. Santa Monica, CA: RAND: 2001. Retrieved October 19, 2007.  
[http://www.rand.org/pubs/documented\\_briefings/DB339/](http://www.rand.org/pubs/documented_briefings/DB339/)
  
- [6] VV&A Recommended Practices Guide. Retrieved November 24, 2007,  
[wa.dmsomil/Ref\\_Docs/VVTechnical/wtechniques.htm](http://wa.dmsomil/Ref_Docs/VVTechnical/wtechniques.htm) – 592k
  
- [7] DoD 5000.1, 5000.2. Documents. Processes & Methods. Retrieved November 24, 2007, <https://acc.dau.mil/CommunityBrowser.aspx?id=37340&lnag=en-US> – 38k
  
- [8] CJCSI 3170.0 “Joint Capabilities Integration and Development System. Retrieved November 24, 2007, [www.army.thewayahead/acpdownloads/3170-01.pdf](http://www.army.thewayahead/acpdownloads/3170-01.pdf)-
  
- [9] *Test & Evaluation Management Guide, Chaps 20&14..* Retrieved November 24, 2007, [www.dau.mil/pubss/gdbks/test\\_eval\\_guide.asp](http://www.dau.mil/pubss/gdbks/test_eval_guide.asp) - 12k
  
- [10] Loughran, Julia. *Simulation Across The Spectrum: Less Is Sometimes More: How Distributed Games Can Be Used for Training and Analysis* September 2001, Retrieved October 29, 2007,  
[http://www.sisostds.org/webletter/siso/iss\\_78/art\\_379.htm](http://www.sisostds.org/webletter/siso/iss_78/art_379.htm)
  
- [11] *C4ISR/Sim Technical Reference Model Study Group Final Report (C4ISR/Sim TRM)* Retrieved November 24, 2007, [www.sisostds.org](http://www.sisostds.org)

- 1) Course name: Components of Logistics Systems
- 2) Course coordinator: Marsha Taliaferro-Gillis, Ph.D.  
6596 Main Street  
Gloucester, VA 23061  
(804)694-3173 (Office)  
(804)824-4663 (Cell)  
mtgillis@werneranderson.com
- 3) Course description: M&S applications for each of the components of logistics systems, including supply chain, storage systems, facilities, production, inventory management, transportation/distribution, and replenishment policies.
- 4) Modules incorporated into Course - O5
- 5) ESRs that the course supports and corresponding level of mastery.
  - b) Best practices of modeling methods and strategic supply chain design.  
*Competency Level: General Awareness*
  - c) Comprehension of advantages/disadvantages of different supply chain methods and potential analysis of supply chains.  
*Competency Level: General Awareness*
  - d) Recognizing the role of constraints and the methods for capturing them in structuring a production or distribution network.  
*Competency Level: General Awareness and Understanding*
  - e) Understand the role of data in logistics modeling, and planning logistic responsiveness in operations, while supporting the importance of sensitivity analysis to input data and analysis drivers.  
*Competency Level: General Awareness and Understanding*
  - f) Evaluation of how to integrate end-to-end logistics system modeling from production by creating supply chains for competitive advantage.  
*Competency Level: General Awareness and Understanding*
  - f) Application of methods used in modeling a supply chain.  
*Competency Level: Application and Mastery*
  - g) Analysis of methods in modeling a storage system and integrating models for multi-storage systems.  
*Competency Level: Application and Mastery*
  - h) Analysis of methods in modeling a production facility with planning and sourcing supply chain operations.

*Competency Level: Application and Mastery*

- i) Application of methods used in modeling inventory management and planning framework for logistics and the supply chain.

*Competency Level: Application and Mastery*

- j) Understand the methods used in modeling a distribution network involving the role of intermediate nodes and nonlinear costs.

*Competency Level: Mastery*

- k) Explain the methods used and the components considered in modeling replenishment policies with a single period inventory model to account for demand surprises.

*Competency Level: Mastery*

- 6) Prerequisites assumed, and corresponding level of mastery. Mastery of Introductory College Level of M&S as demonstrated by a final grade of not less than a B.

- 7) Course Maturity: None

- 8) Number of contact hours and pace contemplated: 3 hours lecture/week for 9 weeks.

- 9) Proposed Delivery modality is face-to-face and/or online.

- 10) Module learning objectives:

- O5.1 Identify the methods and characteristics of different supply chain, et al modeling methods (e.g., discrete event simulation, constraint optimization, spreadsheet, network design, rough cut methods, discrete vs. stochastic).
- O5.2 Describe the advantages/disadvantages to different methods of different supply chain, et al modeling methods (discrete event simulation, constraint optimization, and spreadsheet).
- O5.3 Understand the role of constraints and the methods for capturing them in various modeling methodologies.
- O5.4 Understand the role of data in logistics modeling, the challenges in obtaining data, and the importance of sensitivity analysis of input data and of analysis drivers.
- O5.5 Understand how to integrate end-to-end logistics system modeling from production and the start of the supply chain to distribution and the setting of replenishment policies.
- O5.6 Given a case study, apply or analyze the methods used and the components considered in modeling a supply chain.
- O5.7 Given a case study, apply or analyze the methods used and the components considered in modeling a storage system.

- O5.8 Given a case study, apply or analyze the methods used and the components considered in modeling a production facility.
- O5.9 Given a case study, apply or analyze the methods used and the components considered in modeling inventory management.
- O5.10 Give a case study, apply or analyze the methods used and the components considered in modeling a distribution network.
- O5.11 Given a case study, apply or analyze the methods used and the components considered in modeling replenishment policies.

11) Course learning objectives- Mastery of methods and characteristics of different supply chain, et al modeling methods using the role of constraints and the methods for capturing them in various modeling methodologies. Mastery of the role of data in logistics modeling, the challenges in obtaining data, and how important sensitivity analysis can be for input data of analysis drivers. Mastery of methods used and components considered in modeling a supply chain and analysis of methods used and components considered in modeling inventory management. Mastery to be demonstrated by a score of 90% correct responses on a final exam in a multiple choice format.

12).Course assessment plan: final exam in a multiple choice format

13).Topic list by hour of instruction and reference:

*Competency Level: General Awareness*

- i) Hour 1: (Sub ESR O5.1). Define the methods and characteristics of different supply chain, et al modeling methods (e.g., discrete event simulation, constraint optimization, spreadsheet, network design, rough cut methods, discrete vs. stochastic). [1]

*Competency Level: General Awareness*

- ii) Hour 2: (Sub ESR O5.2). List the advantages/disadvantages to different methods of different supply chains, et al modeling methods (discrete event simulation, constraint optimization, and spreadsheet). [1]

*Competency Level: General Awareness*

- iii) Hour 3: (Sub ESR O5.3). Describe the role of constraints and the methods for capturing them in various modeling methodologies. [2]

*Competency Level: Understanding*

- iv) Hour 4: (Sub ESR O5.3). Use the role of constraints and the methods for capturing them in various modeling methodologies. [2]

*Competency Level: General Awareness*

- v) Hour 5: (Sub ESR O5.4). Describe the role of data in logistics modeling, the challenges in obtaining data, and the importance of sensitivity analysis of input data of analysis drivers. [3]

*Competency Level: Understanding*

- vi) Hour 6: (Sub ESR O5.4). Summarize the role of data in logistics modeling, the challenges in obtaining data, and how importance of sensitivity analysis of input data of analysis drivers. [3]

*Competency Level: General Awareness*

- vii) Hour 7: (Sub ESR O5.5). Distinguish how to integrate end-to-end logistics system modeling from production and how to start a supply chain to distribute and replenish policies. [4]

*Competency Level: Understanding*

- viii) Hour 8: (Sub ESR O5.5). Demonstrate how to integrate end-to-end logistics system modeling from production and how to start a supply chain to distribute and replenish policies. [5]

*Competency Level: Understanding*

- ix) Hour 9: (Sub ESR O5.5). Interpret how to integrate end-to-end logistics system modeling from production and how to start a supply chain to distribute and replenish policies. [4]

*Competency Level: Application*

- x) Hour 10: (Sub ESR O5.6). Given a case study, apply the methods used and the components considered in modeling a supply chain. [1]

*Competency Level: Mastery*

- xi) Hour 11: (Sub ESR O5.6). Given a case study, differentiate between the methods used and the components considered in modeling a supply chain. [6]

*Competency Level: Mastery*

- xii) Hour 12: (Sub ESR O5.6). Given a case study, differentiate between the methods used and the components considered in modeling a supply chain. [4]

*Competency Level: Application*

- xiii) Hour 13: (Sub ESR O5.7). Given a case study, demonstrate the methods used and the components considered in modeling a storage system. [4]

*Competency Level: Mastery*

- xiv) Hour 14: (Sub ESR O5.7). Given a case study, analyze the methods used and the components considered in modeling a storage system. [4]

*Competency Level: Mastery*

- xv) Hour 15: (Sub ESR O5.7). Given a case study, illustrate the methods used and the components considered in modeling a storage system. [1]



*Competency Level: Application*

- xvi) Hour 16: (Sub ESR O5.8). Demonstrate how to integrate end-to-end logistics system modeling from production and the start of the supply chain to the distribution and the setting of replenishment policies. [7]

*Competency Level: Mastery*

- xvii) Hour 17: (Sub ESR O5.8). Demonstrate how to integrate end-to-end logistics system modeling from production and the start of the supply chain to the distribution and the setting of replenishment policies. [1]

*Competency Level: Mastery*

- xviii) Hour 18: (Sub ESR O5.8). Summarize how to integrate end-to-end logistics system modeling from production and the start of the supply chain to the distribution and the setting of replenishment policies. [7]

*Competency Level: Application*

- xix) Hour 19: (Sub ESR O5.9). Given a case study, demonstrate the methods used and the components considered in modeling inventory management. [7]

*Competency Level: Mastery*

- xx) Hour 20: (Sub ESR O5.9). Given a case study, demonstrate the methods used and the components considered in modeling inventory management. [7]

*Competency Level: Application*

- xxi) Hour 21: (Sub ESR O5.9). Given a case study, apply the methods used and the components considered in modeling inventory management. [1]

*Competency Level: Mastery*

- xxii) Hour 22: (Sub ESR O5.10). Give a case study, justify the methods used and the components considered in modeling a distribution network. [2]

*Competency Level: Mastery*

- xxiii) Hour 23: (Sub ESR O5.10). Give a case study, justify the methods used and the components considered in modeling a distribution network. [2]

*Competency Level: Mastery*

- xxiv) Hour 24: (Sub ESR O5.10). Give a case study, compare the methods used and the components considered in modeling a distribution network. [2]

*Competency Level: Application*

- xxv) Hour 25: (Sub ESR O5.11). Given a case study, compare the methods used and the components considered in modeling replenishment policies. [6]

*Competency Level: Mastery*

- xxvi) Hour 26: (Sub ESR O5.11). Given a case study, describe the methods used and the components considered in modeling replenishment policies.  
[6]

*Competency Level: Mastery*

- xxvii) Hour 27 (Sub ESR O5.11). Given a case study, describe the methods used and the components considered in modeling replenishment policies.  
[6]

14) Proposed references and texts:

- [1] Stadtler, H., C. Kilger. 2005. *Supply Chain Management and Advanced Planning: Concepts, Models, Software and Case Studies*, Springer Berlin, Heidelberg, Germany.
- [2] Brandimarte, Zotteri 2006. *Introduction to Distribution Logistics*, John Wiley and Sons Inc. Hoboken, New Jersey
- [3] Kress, M. 2002. *Operational Logistics: The Art and Science of Sustaining Military Operations*. Kluwer Academic Publishers, Norwell, MA.
- [4] Hugos, M. 2006. *Essentials of Supply Chain Management*, 2nd Ed. John Wiley & Sons, Inc, Hoboken, NJ.
- [5] The Defense Acquisition University Press, *Test and Evaluation Management Guide*, 5th Ed 2005.Fort Belvoir, VA.-
- [6] Rahim, M.A. 2001. *Integrated Models in Production Planning, Inventory, Quality, and Maintenance*, Kluwer Academic Publishers, Norwell, MA.
- [7] Rushton, A., Croucher, P., Peter Baker. 2006. *The Handbook of Logistics and Distribution Management*, 3rd Ed. Bell & Bain, Glasgow, United Kingdom.

- 1) Course Name: Data Strategy
- 2) Course coordinator: Marsha Taliaferro-Gillis, Ph.D.  
6596 Main Street  
Gloucester, VA 23061  
(804)694-3173 (Office)  
(804)824-4663 (Cell)  
mtgillis@werneranderson.com
- 3) Course description: Data strategy for an M&S effort including estimating the resources necessary to obtain sufficient data to populate the model.
- 4) Modules incorporated into Course - P15
- 5) ESRs that the course supports and the corresponding level of mastery.
  - a) Role of data in M&S application and development  
*Competency Level: General Awareness and Understanding*
  - b) Data formats for M&S applications  
*Competency Level: General Awareness*
  - c) Good data management  
*Competency Level: General Awareness and Understanding*
  - d) Sources of data for M&S and data repositories  
*Competency Level: General Awareness*
  - e) Minimum data requirements for the decision context  
*Competency Level: Understanding and Mastery*
  - f) Sufficient data validation  
*Competency Level: Understanding and Mastery*
  - g) Impact and cost of low quality data  
*Competency Level: General Awareness and Mastery*
  - h) Impact and cost of data unavailability  
*Competency Level: Understanding and Mastery*
- 6) Prerequisites assumed, and corresponding level of mastery: Mastery of College Level Calculus II and Introduction to M&S as demonstrated by a final grade of not less than a B.

- 7) Course maturity: none
- 8) Number of contact hours and pace contemplated: 2 hours lecture/week for 10 weeks
- 9) Proposed Delivery modality: face-to-face and/or on-line
- 10) Module learning objectives:
  - P15.1 Understand the role of data in M&S application and development
  - P15.2 Identify common data formats for M&S applications
  - P15.3 Understand fundamentals of good data management practices
  - P15.4 Identify common sources of data for M&S and data repositories
  - P15.5 Given a case study, identify the minimum data requirements for the decision context
  - P15.6 Given a case study and a sample V&V report, evaluate whether the data validation is sufficient for the specific use
  - P15.7 Given a case study and a sample V&V report, evaluate the impact and cost of low quality data on simulation output
  - P15.8 Given a case study and V&V report, assess the impact and cost of data unavailability
- 11) Course Learning Objectives: Mastery of strategies needed for ability to estimate resources necessary for obtaining sufficient data for populating an M&S project. Mastery to be demonstrated by a grade of not less than a B+ on a project and a final course exam.
- 12) Course assessment plan: projects, and exams
- 13) Topic list by hour of instruction and reference.

*Competency Level: General Awareness*

- 1) Hour 1: (Sub ESR P15.1). Learn the role of data in M&S application and development. [1]

*Competency Level: Understanding*

- 2) Hour 2: (Sub ESR P15.1). Understand the role of data in M&S application and development. [2]

*Competency Level: Understanding*

- 3) Hour 3: (Sub ESR P15.1). Understand the role of data in M&S application and development. [2]

*Competency Level: General Awareness*

- 4) Hour 4: (Sub ESR P15.2). Learn common data formats for M&S applications. [3]

*Competency Level: General Awareness*

- 5) Hour 5: (Sub ESR P15.2). Learn common data formats for M&S applications. [3]

*Competency Level: General Awareness*

- 6) Hour 6: (Sub ESR P15.3). Learn the fundamentals of good data management practices. [4]

*Competency Level: Understanding*

- 7) Hour 7: (Sub ESR P15.3). Understand the fundamentals of good data management practices. [5]

*Competency Level: Understanding*

- 8) Hour 8: (Sub ESR P15.3). Understand the fundamentals of good data management practices. [6]

*Competency Level: Understanding*

- 9) Hour 9: (Sub ESR P15.3). Understand the fundamentals of good data management practices. [6]

*Competency Level: General Awareness*

- 10) Hour 10: (Sub ESR P15.4). Learn the common sources of data for M&S and data repositories. [6]

*Competency Level: Understanding*

- 11) Hour 11: (Sub ESR P15.5). Given a case study, identify the minimum data requirements for the decision context. [6]

*Competency Level: Mastery*

- 12) Hour 12: (Sub ESR P15.5). Given a case study, analyze the minimum data requirements for the decision context. [6]

*Competency Level: Mastery*

- 13) Hour 13: (Sub ESR P15.5). Given a case study, analyze the minimum data requirements for the decision context. [6]

*Competency Level: Understanding*

- 14) Hour 14: (Sub ESR P15.6). Given a case study and a sample V&V report, determine whether the data validation is sufficient for the specific use. [7]

*Competency Level: Mastery*

- 15) Hour 15: (Sub ESR P15.6). Given a case study and a sample V&V report, evaluate whether the data validation is sufficient for the specific use. [7]

*Competency Level: Mastery*

- 16) Hour 16: (Sub ESR P15.6). Given a case study and a sample V&V report, evaluate whether the data validation is sufficient for the specific use. [7]

*Competency Level: General Awareness*

- 17) Hour 17: (Sub ESR P15.7). Given a case study and a sample V&V report, learn [7]

*Competency Level: Mastery*

- 18) Hour 18: (Sub ESR P15.7). Given a case study and a sample V&V report, evaluate the impact and cost of low quality data on simulation output. [8]

*Competency Level: Understanding*

- 19) Hour 19: (Sub ESR P15.8). Given a case study and V&V report, understand the impact and cost of data unavailability. [8]

*Competency Level: Mastery*

- 20) Hour 20: (Sub ESR P15.8). Given a case study and V&V report, analyze the impact and cost of data unavailability. [8]

14) Proposed references and texts:

[1] Chung, Christopher A.. 2004. *Simulation Modeling Handbook: A Practical Approach*. CRC Press LLC. Boca Raton, Florida.

[2] Zeigler, Bernard P., Hammonds, (Phillip E.. 2007. Modeling & Simulation-Based Data Engineering: Introducing Pragmatics into Ontologies for Net-Centric Information Exchange, Elsevier Inc., London, UK)

[3] Tolk, Adreas. 2003. Common Data Administration, Data Management, and Data Alignment as a Necessary Requirement for Coupling C4ISR Systems and M&S Systems. *INFORMATION & SECURITY: An International Journal*. Vol. 12, No. 2. 164-174 [http://cms.isn.ch/public/docs/doc\\_6954\\_259\\_en.pdf](http://cms.isn.ch/public/docs/doc_6954_259_en.pdf).

[4] Simsion, Graeme. 2007. Data Modeling Theory and Practice. Technics Publications LLC, Bradley Beach NJ.

[5] Vakali, Athena. 2007. *Web Management Data Practices: Emerging Techniques and Technologies*. Idea Group Inc, Hershey PA.

[6] Reingruber, Michael C., Gregory, William W. 1994. *The Data Modeling Handbook: A Best Practice Approach to Building Quality Data Models*, John Wiley and Sons, Inc, Canada.

- [7] Sadowski, Deborah A., Brabau, Mark R., Tips for Successful Practice of Simulation. 1999. Farrington, P. A., Nembhard, H. B., Sturrock D. T., Evans G. W., eds. Winter Simulation Conference. December 1999 Phoenix AZ USA.  
<http://www.informs-sim.org/wsc99/008.PDF>
- [8] Ören, Tuncer I., 2001. *Impact of Data on Simulation: From Early Practices to Federated and Agent-Directed Simulation*. Heemik et al, eds. *Proc. Of EUROISM 2001*. Delft, The Netherlands. <http://www.wite.uottawa.ca/~oren/pubs-2001-04-Delft-Data.pdf>.

- 1) Course name: Estimation of Measures
- 2) Course coordinator: Marsha Taliaferro-Gillis, Ph.D.  
6596 Main Street  
Gloucester, VA 23061  
(804)694-3173 (Office)  
(804)824-4663 (Cell)  
mtgillis@werneranderson.com
- 3) Course description: Level of detail of a model with that of the information needed to support a decision, and understand the connection between the decision to be made and the estimation of measures from the model.
- 4) Modules incorporated into Course - P11
- 5) ESRs that the course supports and the corresponding level of mastery
  - a) Detail, fidelity, aggregation, and disaggregation  
Competency Level: General Awareness
  - b) Intended and specific use within context of VV&A  
Competency Level: General Awareness and Understanding
  - c) Relationship between simulation level of detail and decision criteria  
Competency Level: General Awareness and Understanding
  - d) Various group models according to their levels of detail  
Competency Level: Understanding
  - e) Decision criteria that can be supported by M&S  
Competency Level: Understanding and Mastery
  - f) Basic concepts of input and output analysis with respect to a simulations measure of effectiveness  
Competency Level: General Awareness and Understanding
  - g) Identify if the level of detail in a simulation output to see if it matches the decision criteria  
Competency Level: Understanding and Mastery
  - h) Assess if modifications of input and output parameters are appropriate for a specific use  
Competency Level: Understanding and Mastery



- 6) Prerequisites assumed, and corresponding level of mastery: Mastery of College Level Calculus II and Introduction to M&S as demonstrated by a final grade of not less than a B.
- 7) Course maturity: none
- 8) Number of contact hours and pace contemplated: 3 hours lecture/week for 6 weeks
- 9) Proposed Delivery modality: face-to-face and/or on-line
- 10) Module learning objectives:
  - P11.1 Define the level of detail, fidelity, aggregation, and disaggregation/
  - P11.2 Understand intended use and specific use within the context of VV&A/
  - P11.3 Describe the relationship between simulation level of detail and decision criteria.
  - P11.4 Understand various group models according to their levels of detail.
  - P11.5 Given a case study and V&V report, identify the decision criteria that can be supported by M&S.
  - P11.6 Understand the basic concepts of input and output analysis with respect to a simulations measure of effectiveness.
  - P11.7 Given a case study, identify if the level of detail in a simulation output to see if it matches the decision criteria.
  - P11.8 Given a case study and sample V&V report assess if modifications of input and output parameters are appropriate for a specific use.
- 11) Course learning objectives: Mastery of basic concepts of input and output analysis, simulation measures of effectiveness, and intended and specific uses of VV&A. Mastery is to be demonstrated by passing grades of at least B+ on both projects and exams.
- 12) Course assessment plan: projects and exams
- 13) Topic list by hour of instruction and reference.

*Competency Level: General Awareness*

- 1) Hour 1: (Sub ESR P11.1). Review the need of levels of detail, fidelity, aggregation, and disaggregation in M&S. [1]

*Competency Level: General Awareness*

- 2) Hour 2: (Sub ESR P11.2). Learn the intended and specific use within the context of VV&A. [2] [3]

*Competency Level: Understanding*

- 3) Hour 3: (Sub ESR P11.2). Understand the intended and specific use within the context of VV&A. [1]

*Competency Level: General Awareness*

- 4) Hour 4: (Sub ESR P11.3). Learn the relationship between the simulation level of detail and decision criteria. [2] [3]

*Competency Level: Understanding*

- 5) Hour 5: (Sub ESR P11.3). Understand the relationship between the simulation level of detail and decision criteria. [4]

*Competency Level: Understanding*

- 6) Hour 6: (Sub ESR P11.4). Understand various group models according to their levels of detail. [2] [3]

*Competency Level: Understanding*

- 7) Hour 7: (Sub ESR P11.5). Given a case study and V&V report, identify the decision criteria that can be supported by M&S. [5]

*Competency Level: Mastery*

- 8) Hour 8: (Sub ESR P11.5). Given a case study and V&V report, analyze the decision criteria that can be supported by M&S. [5]

*Competency Level: Mastery*

- 9) Hour 9: (Sub ESR P11.5). Given a case study and V&V report, analyze the decision criteria that can be supported by M&S. [5]

*Competency Level: General Awareness*

- 10) Hour 10: (Sub ESR P11.6). Learn the basic concepts of input and output analysis with respect to the simulations measure of effectiveness. [3]

*Competency Level: Understanding*

- 11) Hour 11: (Sub ESR P11.6). Understand the basic concepts of input and output analysis with respect to the simulations measure of effectiveness. [6]

*Competency Level: Understanding*

- 12) Hour 12: (Sub ESR P11.6). Review the basic concepts of input and output analysis with respect to the simulations measure of effectiveness. [6]

*Competency Level: Understanding*

- 13) Hour 13: (Sub ESR P11.7). Given a case study, determine if the level of detail in a simulation output matches the decision criteria. [4]

*Competency Level: Mastery*

- 14) Hour 14: (Sub ESR P11.7). Given a case study, analyze the level of detail in a simulation output to see if it matches the decision criteria. [4]

*Competency Level: Mastery*

- 15) Hour 15: (Sub ESR P11.7). Given a case study, analyze the level of detail in a simulation output to see if it matches the decision criteria. [4]

*Competency Level: Understanding*

- 16) Hour 16: (Sub ESR P11.8). Given a case study and sample V&V report, determine if modifications of input and output parameters are appropriate for a specific use. [4]

*Competency Level: Mastery*

- 17) Hour 17: (Sub ESR P11.8). Given a case study and sample V&V report, assess if modifications of input and output parameters are appropriate for a specific use. [4]

*Competency Level: Mastery*

- 18) Hour 18: (Sub ESR P11.8). Given a case study and sample V&V report, assess if modifications of input and output parameters are appropriate for a specific use. [4]

#### 14) Proposed references and texts:

- [1] Zeigler, Bernard P., [Tag Gon Kim](#), [Herbert Praehofer](#). 2000. *Theory of Modeling and Simulation*. Academic Press. San Diego CA.
- [2] Greasley, Andrew. 2004. *Simulation Modeling for Business*. MPG Books Ltd. Great Britain.
- [3] Pooch, Udo W., James A. Wall. 1993. *Discrete Event Simulation a Practical Approach*. CRC Press Inc. Boca Raton, FL.
- [4] Law, Averill M., W. David Kelton. 2000. *Simulation Modeling and Analysis*, 3<sup>rd</sup> ed. McGraw Hill, Boston, MA.
- [5] North, Michael J., Charles M. Macal. 2007. *Managing Business Complexity: Discovering Strategic Solutions with Agent- Based Modeling and Simulation* Oxford University Press Inc. New York, NY.
- [6] Rubinstein, Reuven Y., Benjamin Malamed. 1998. *Modern Simulation and Modeling*, John Wiley and Sons, Canada.

- 1) Course name: Logistics Modeling
- 2) Module coordinator: Marsha Taliaferro-Gillis, Ph.D.  
6596 Main Street  
Gloucester, VA 23061  
(804)694-3173 (Office)  
(804)824-4663 (Cell)  
mtgillis@werneranderson.com
- 3) Course description: Properties of a representative suite of logistics models across the services, including inputs-outputs, assumptions, implementation, cost and time required, adaptability, extensibility, and VV&A status.
- 4) Modules incorporated into Course - O3
- 5) ESRS that the course supports and corresponding level of mastery.
  - a) : Levels of detail typically included in logistics analyses.  
Competency Level: General Awareness
  - b) Prospective logistics models from a list of models.  
Competency Level: General Awareness
  - c) Levels of detail typically included in logistics analyses  
Competency Level: General awareness
  - d) The role of aggregation across logistical levels of detail.  
Competency Level: General Awareness
  - e) Developing quantifiable metrics in meeting mission requirements affordably  
Competency Level: General awareness and Understanding
  - f) Differences in data requirements at different levels of abstraction  
Competency Level: General Awareness and Understanding
  - g) The role of modeling inputs and assumptions in developing operational analysis  
Competency Level: General Awareness
  - h) Sensitivity analysis of critical assumptions for solution outputs in logistics  
Competency Level: Understanding
  - i) Effectiveness of logistical samples in evaluating modeling requirements  
Competency Level: Application and Mastery

6) Prerequisites assumed, and corresponding level of mastery: Introductory course in M&S with a final grade of not less than B.

7) Module maturity: none

8) Number of hours estimated to teach module:

9) Proposed Delivery modality: face-to-face and/or on-line

10) Module learning objectives:

- O3.1 Identify levels of detail typically included in logistics analyses.
- O3.2 Identify prospective logistics models from a list of models.
- O3.3 Identify levels of detail typically included in logistics analyses.
- O3.4 Understand the role of aggregation across logistical levels of detail.
- O3.5 Understand the importance of developing quantifiable metrics of performance to meet mission requirements affordably
- O3.6 Understand the difference in data requirements at different levels of abstraction
- O3.7 Describe the role of modeling inputs and assumptions in developing operational analysis (scenario & threat, missions, alternatives, required input data, operations concepts, basing & deployment, support concepts, [MAIS AoA: organizational missions, functions, & objective]).
- O3.8 Understand the importance of sensitivity analysis of critical assumptions in determining solution output
- O3.9 Given a case study, assess the effectiveness of a sample suite of logistical models in evaluating the full range of logistical requirements (reliability, effectiveness, logistics footprint, supportability criteria, etc.) to sustain the mission over long term.

11) .Course learning objectives: Mastery of a suite of logistics models across the services, including inputs-outputs, assumptions, implementation, cost and time required, adaptability, extensibility, and VV&A status. Mastery to be demonstrated by a grade of not less than B+ on projects and exams.

12) Course assessment plan: projects and exams

13) Topic list by hour of instruction and reference:

*Competency Level: General Awareness*

- 1) Hour one: (Sub ESR O3.1). Identify levels of detail typically included in logistics analyses. [1]

*Competency Level: General Awareness*

- 2) Hour two: (Sub ESR O3.2). Identify prospective logistics models from a list of models. [1] [2]

*Competency Level: General Awareness*

- 3) Hour three: (Sub ESR O3.3). Identify levels of detail typically included in logistics analyses. [1]

*Competency Level: Understanding*

- 4) Hour four: (Sub ESR O3.4). Understand the role of aggregation across logistical levels of detail. [2]

*Competency Level: Understanding*

- 5) Hour five: (Sub ESR O3.4). Understand the role of aggregation across logistical levels of detail. [3]

*Competency Level: General Awareness*

- 6) Hour six: (Sub ESR O3.5). Understand the importance of developing quantifiable metrics of performance to meet mission requirements affordably. [3]

*Competency Level: Understanding*

- 7) Hour seven: (Sub ESR O3.5). Understand the importance of developing quantifiable metrics of performance to meet mission requirements affordably. [1]

*Competency Level: General Awareness*

- 8) Hour eight: (Sub ESR O3.6). Understand the difference in data requirements at different levels of abstraction. [1]

*Competency Level: Understanding*

- 9) Hour nine: (Sub ESR O3.6). Understand the difference in data requirements at different levels of abstraction. [1]

*Competency Level: General Awareness*

- 10) Hour ten: (Sub ESR O3.7). Describe the role of modeling inputs and assumptions in developing operational analysis (scenario & threat, missions, alternatives, required input data, logistics concept, basing & deployment, support concept, [MAIS AoA: organizational missions, functions, & objective]). [2]

*Competency Level: General Awareness*

- 11) Hour eleven: (Sub ESR O3.7). Describe the role of modeling inputs and assumptions in developing operational analysis (scenario & threat, missions, alternatives, required input data, operations concept, basing & deployment, support concept, [MAIS AoA: organizational missions, functions, & objective]). [2]

*Competency Level: General Awareness*

- 12) Hour twelve: (Sub ESR O3.8). Understand the importance of sensitivity analysis of critical assumptions in determining solution outputs for logistics. [1]

*Competency Level: Understanding*

- 13) Hour thirteen: (Sub ESR O3.8). Understand the importance of sensitivity analysis of critical assumptions in determining solution outputs for logistics. [2]

*Competency Level: Application*

- 14) Hour fourteen: (Sub ESR O3.9). Given a case study, assess the effectiveness of a sample suite of logistical models in evaluating the full range of logistical requirements (reliability, effectiveness, logistics footprint, supportability criteria, etc.) to sustain the mission over long term. [3]

*Competency Level: Mastery*

- 15) Hour fifteen: (Sub ESR O3.9). Given a case study, assess the effectiveness of a sample suite of logistical models in evaluating the full range of logistical requirements (reliability, effectiveness, logistics footprint, supportability criteria, etc.) to sustain the mission over long term. [3] [4]

14) Proposed references and texts:

[1] Kelton, W., A. Law. 2000. *Simulation Modeling and Analysis*, McGraw-Hill, Boston, MA.

[2] Altiook, T., B. Melamed. 2007. *Simulation Modeling and Analysis with ARENA*, Academic Press, Burlington, MA.

[3] Kress, M. 2002. *Operational Logistics: The Art and Science of Sustaining Military Operations*, 1st ed. Springer, Norwell, MA.

[4] Hammonds, P., B. Zeigler 2007. *Modeling and Simulation - Based Data Engineering: Introducing Pragmatics Into Ontologies for Net-Centric Information Exchange*, Burlington, MA

- 1) Course name: M&S in the Contract Proposal Process
- 2) Course coordinator: Marsha Taliaferro-Gillis, Ph.D.  
6596 Main Street  
Gloucester, VA 23061  
(804)694-3173 (Office)  
(804)824-4663 (Cell)  
mtgillis@werneranderson.com
- 3) Course description: Recognize contracting issues for M&S products. Include considerations for intellectual property issues, delivery terms, maintenance responsibility, standards for documentation, open architecture, interoperability, reuse and other considerations
- 4) Modules incorporated into the Course - A4
- 5) ESRs that the course supports and corresponding level of mastery.
  - a) Intellectual Property Issues in Contracting for M&S products  
*Competency Level: Understanding*
  - b) Terms of Delivery and Contracting for M&S products  
*Competency Level: Understanding*
  - c) Documentation Deliverables  
*Competency Level: Understanding*
  - d) Long-term Maintenance for Contracted M&S products.  
*Competency Level: Understanding*
  - e) Open Architecture  
*Competency Level: Understanding*
  - f) Interoperability  
*Competency Level: Understanding*
  - g) M&S Re-use  
*Competency Level: Understanding*
  - h) Enforcing M&S Contract Terms  
*Competency Level: Understanding*
  - i) Drafting M&S contract documents  
*Competency Level: Mastery*



- 6) Prerequisites assumed, and corresponding level of mastery:
- 7) Course maturity: none
- 8) Number of contact hours and pace contemplated: 3 hours lecture/week for 6 weeks
- 9) Proposed Delivery modality: face-to-face and/or on-line.
- 10) Module learning objectives:

- A4.1 Describe the Intellectual Property issues that arise when contracting for M&S products.
- A4.2 Describe and differentiate between possible Terms of Delivery when contracting for M&S products.
- A4.3 Identify the content, format, and medium the government should require for documentation deliverables.
- A4.4 Understand the long-term maintenance options available to government customers when contracting for M&S products.
- A4.5 Understand issues in using Open Architecture products, including compatibility and continued use of legacy or unsupported systems.
- A4.6 Understand the contract process for issuing M&S requirements and insuring that contractor M&S is interoperable with government and other third-party M&S.
- A4.7 Understand the contractual issues involved with re-use of purchased M&S products.
- A4.8 Understand the options and procedures for enforcing contract terms or resolving contractor disputes with regard to M&S.
- A4.9 Given a case study, assess and revise contract documents to insure that program M&S objectives with regard to IP, delivery, interoperability, maintenance, and reuse are met and enforced.

- 11) Course learning objectives: Mastery of M&S contracting issues including IP issues, delivery and maintenance terms, reuse, interoperability, and contract enforcement.

- 12) Course assessment plan: Projects and Exams

- 13) Topic list by hour of instruction and reference:

*Competency Level: General Awareness*

- 1) Hour one: (Sub ESR A4.1). Introduction and Overview (course notes and syllabus). [1]

*Competency Level: General Awareness*

- 2) Hour two: (Sub ESR A4.1). Intellectual Property Issues in Contracting for M&S products. [1]

*Competency Level: Understanding*

- 3) Hour three: (Sub ESR A4.1). Intellectual Property Issues in Contracting for M&S products. [1]

*Competency Level: General Awareness*

- 4) Hour four: (Sub ESR A4.2). Terms of Delivery and Contracting for M&S products. [2]

*Competency Level: Understanding*

- 5) Hour five: (Sub ESR A4.3). Terms of Delivery and Contracting for M&S products. [2]

*Competency Level: Understanding*

- 6) Hour six: (Sub ESR A4.3). Documentation Deliverables. [3]

*Competency Level: General Awareness*

- 7) Hour seven: (Sub ESR A4.4). Long-term Maintenance for Contracted M&S products. [2]

*Competency Level: Understanding*

- 8) Hour eight: (Sub ESR A4.4). Long-term Maintenance for Contracted M&S products. [2]

*Competency Level: General Awareness*

- 9) Hour nine: (Sub ESR A4.5). Issues with using Open Architecture. [2]  
[4]

*Competency Level: Understanding*

- 10) Hour ten: (Sub ESR A4.5). Issues with using Open Architecture. [2] [4]

*Competency Level: General Awareness*

- 11) Hour eleven: (Sub ESR A4.6). Insuring Interoperability. [4] [5]

*Competency Level: Understanding*

- 12) Hour twelve: (Sub ESR A4.6). Insuring Interoperability. [4] [5]

*Competency Level: Understanding*

- 13) Hour thirteen: (Sub ESR A4.7). Planning for Re-use. [2]

*Competency Level: Understanding*

- 14) Hour fourteen: (Sub ESR A4.8). Enforcing M&S Contract Terms. [2]

*Competency Level: Understanding*

- 15) Hour fifteen: (Sub ESR A4.9). M&S Contract Project. [2]

*Competency Level: Application*

16) Hour sixteen: (Sub ESR A4.9). M&S Contract Project. [2]

*Competency Level: Mastery*

17) Hour seventeen: (Sub ESR A4.9). M&S Contract Project. [2]

*Competency Level: Mastery*

18) Hour eighteen: (Sub ESR A4.9). M&S Contract Project. [2]

14) Proposed references and texts:

[1] DoD Office of Acquisition Initiatives. 2001. *Intellectual Property: Navigating Through Commercial Waters*.

<http://www.acq.osd.mil/dpap/specificpolicy/intelprop.pdf>

[2] DoD. 2004. *Defense Acquisition Guidebook*. <https://akss.dau.mil/dag/>

[3] DoD. 1993. *Procedures for the Acquisition and Management of Technical Data* (5010.12-M).

[4] Department of the Navy. 2006. *Naval Open Architecture Contract Guidebook*. <https://acc.dau.mil/oa>

[5] Kuhl, F., R. Weatherly, J. Dahmann, *Creating Computer Simulation Systems: An Introduction to the High Level Architecture*. Prentice-Hall, Saddle River, NJ, 2000

- 1) Course name: M&S Proposals
- 2) Course coordinator: Marsha Taliaferro-Gillis, Ph.D.  
6596 Main Street  
Gloucester, VA 23061  
(804)694-3173 (Office)  
(804)824-4663 (Cell)  
mtgillis@werneranderson.com
- 3) Course description: Discernment between M&S proposals, relative to measurable program contributions. Decision making on the appropriate program office level of expenditure on M&S tools throughout the program life cycle. Decisions as to whether custom or off-the-shelf products will be best suited for the program's purpose.
- 4) Modules incorporated into the Course: A3
- 5) ESRs that the course supports and corresponding level of mastery.
  - a) The role of M&S throughout the acquisition cycle  
*Competency Level: General Awareness*
  - b) M&S Support Plan.  
*Competency Level: General Awareness*
  - c) Legacy, developmental, GOTS and COTS M&S.  
*Competency Level: General Awareness*
  - d) The V&V process.  
*Competency Level: Understanding*
  - e) M&S reuse.  
*Competency Level: Understanding*
  - f) Application of a sample M&S Support Plan  
*Competency Level: Application*
  - g) Development of an M&S budget.  
*Competency Level: Mastery*
  - h) Analysis and selection from available M&S options.  
*Competency Level: Mastery*
- 6) Prerequisites assumed, and corresponding level of mastery. General awareness of the government acquisition process.

- 7) Course maturity: none
- 8) Number of contact hours and pace contemplated: 2.5 hours lecture/week for 8 weeks
- 9) Proposed Delivery modality; face-to-face and/or on-line.
- 10) Module learning objectives:
  - A3.1 Define the role of M&S throughout the acquisition cycle (e.g., Concept Development, DT&E, OT&E, LFT&E, and operations and sustainment)
  - A3.2 Describe the use of an M&S Support Plan throughout the acquisition cycle.
  - A3.3 Define and distinguish between legacy, developmental, GOTS and COTS M&S.
  - A3.4 Understand the V&V process and its impact on M&S usage, acceptability, and cost.
  - A3.5 Understand the benefit and application of M&S reuse across programs and across a single program's lifecycle.
  - A3.6 Apply a sample M&S Support Plan to provide best use of M&S across all stages of the acquisition life-cycle.
  - A3.7 Given a case study and sample M&S Support Plan, develop an M&S budget.
  - A3.8 Given a case study and sample M&S Support Plan, select between available legacy, developmental, GOTS and COTS M&S options.
- 11) Course learning objectives: Mastery of M&S management in the acquisition lifecycle including development and use of an MSSP and evaluation and selection of appropriate and cost effective M&S products. Mastery to be demonstrated by a grade of not less than B+ on final projects and exams.
- 12) Course assessment plan: projects and exams.
- 13) Topic list by hour of instruction and reference:

*Competency Level: General Awareness*

- 1) Hour 1: (Sub ESR A3.1). Introduction and Overview (course notes and syllabus). [1]

*Competency Level: General Awareness*

- 2) Hour 2: (Sub ESR A3.1). The Role of M&S in Concept Development and DT&E. [1]

*Competency Level: General Awareness*

- 3) Hour 3: (Sub ESR A3.1). The Role of M&S in OT&E, LFT&E, and Operations and Sustainment. [1]

*Competency Level: General Awareness*

- 4) Hour 4: (Sub ESR A3.2). The Modeling and Simulation Support Plan. [1]  
[2]

*Competency Level: General Awareness*

- 5) Hour 5: (Sub ESR A3.2). The MSSP; Requirements Across the Services and Best Practices. [2]

*Competency Level: General Awareness*

- 6) Hour 6: (Sub ESR A3.3). M&S Types and Sources. [3]

*Competency Level: General Awareness*

- 7) Hour 7: (Sub ESR A3.4). Verification and Validation Overview. [4]

*Competency Level: Understanding*

- 8) Hour 8: (Sub ESR A3.4). V&V and M&S application, acceptability and cost. [4]

*Competency Level: Understanding*

- 9) Hour 9: (Sub ESR A3.4). V&V and M&S application, acceptability and cost. [4]

*Competency Level: General Awareness*

- 10) Hour 10: (Sub ESR A3.5). M&S Use and Re-use Across Single Program Lifecycle. [1] [5]

*Competency Level: Understanding*

- 11) Hour 11: (Sub ESR A3.5). M&S Use and Re-use Across Multiple Programs. [1] [5]

*Competency Level: General Awareness*

- 12) Hour 12: (Sub ESR A3.6). MSSP Application Project. [1] [5]

*Competency Level: Understanding*

- 13) Hour 13: (Sub ESR A3.6). MSSP Application Project. [1] [5]

*Competency Level: Application*

- 14) Hour 14: (Sub ESR A3.6). MSSP Application Project. [1] [5]

*Competency Level: Application*

- 15) Hour 15: (Sub ESR A3.6). MSSP Application Project. [1] [5]

*Competency Level: Mastery*

- 16) Hour 16: (Sub ESR A3.7). MSSP and M&S Budget Project. [1] [5]

*Competency Level: Mastery*

17) Hour 17: (Sub ESR A3.7). MSSP and M&S Budget Project. [1] [5]

*Competency Level: Mastery*

18) Hour 18: (Sub ESR A3.7). MSSP and M&S Budget Project. [1] [5]

*Competency Level: Mastery*

19) Hour 19: (Sub ESR A3.8). MSSP and M&S Selection Project. [1] [5]

*Competency Level: Mastery*

20) Hour 20: (Sub ESR A3.8). MSSP and M&S Selection Project. [1] [5]

14) Proposed references and texts:

[1] DoD. 2004. *Defense Acquisition Guidebook*. <https://akss.dau.mil/dag/>

[2] Department of the Army. 2005. *Simulation Support Planning and Plans*. (DA PAM 5-12) [http://www.army.mil/usapa/epubs/pdf/p5\\_12.pdf](http://www.army.mil/usapa/epubs/pdf/p5_12.pdf)

[3] Rubenstein, R. Y., B. Melamel. 1998. *Modern Simulation and Modeling*. John Wiley and Sons, Inc., New York, NY.

[4] DoD. 2006. *VV&A Recommended Practices Guide*. <http://vva.dmsomil/>

[5] DoD. 1994. *DoD Directive 5000.59 Modeling and Simulation Management*. <https://www.dmsomil/public/library/policy/policy/d500059p.pdf>

- 1) Course name: M&S Requirements
- 2) Course coordinator: Marsha Taliaferro-Gillis, Ph.D.  
6596 Main Street  
Gloucester, VA 23061  
(804)694-3173 (Office)  
(804)824-4663 (Cell)  
mtgillis@werneranderson.com
- 3) Course description: Establish and write valid modeling and simulation requirements using a process that includes modeling and simulation needs analysis, generation of valid modeling and simulation requirements, functional decomposition and conceptual model development, and issuance of “built to” or “buy to” performance specifications. Understand how models and simulations evolve in fidelity, resolution, and scope as the program life cycle progresses.
- 4) Modules incorporated into the Course - P5
- 5) ESRs that the Course supports and corresponding level of mastery:
  - a) M&S development and VV&A lifecycle  
*Competency Level: Understanding*
  - b) Domains of M&S requirements  
*Competency Level: Understanding*
  - c) Representational requirements in M&S  
*Competency Level: Understanding*
  - d) Conceptual model development and validation  
*Competency Level: General Awareness*
  - e) Process differences between legacy and new development models  
*Competency Level: Understanding*
  - f) Work products available in M&S development  
*Competency Level: Understanding*
  - g) Changes in M&S fidelity, resolution, and scope across the acquisition lifecycle  
*Competency Level: Understanding*
  - h) Acceptability criteria  
*Competency Level: Understanding*



i) Selecting M&S

*Competency Level: Mastery*

j) Developing and Evaluating M&S Requirements

*Competency Level: Mastery*

6) Prerequisites assumed, and corresponding level of mastery: None

7) Module maturity: none

8) Number of contact hours and pace contemplated: 3 hours lecture/week for 8 weeks

9) Proposed Delivery modality is face-to-face and/or on-line.

10) Module learning objectives:

P5.1 Describe the M&S development and VV&A lifecycle (for COTS, GOTS and new development M&S)

P5.2 Identify the three domains of M&S requirements (user domain, problem domain, and simulation domain)

P5.3 Describe the types of representational requirements (e.g., entities, actions, tasks, interactions, behaviors) in M&S and standard methods for capturing them (e.g. UML, conceptual model descriptions)

P5.4 Describe how M&S requirements, representational requirements, acceptability criteria, and intended use support conceptual model development and validation

P5.5 Describe the M&S process differences between legacy (no, minor & major modifications) and new development models

P5.6 Describe the work products available in M&S development and their role in VV&A

P5.7 Describe how M&S fidelity, resolution, and scope changes across the acquisition lifecycle (e.g., concept refinement to DT to OTA to OT to training)

P5.8 Describe the role of acceptability criteria in the VV&A process and its relationship to M&S requirements

P5.9 Given a case study, select those requirements which are appropriate for M&S

P5.10 Given a case study and sample acquisition documents (TEMP, CDD, ICD, PSPEC), develop or evaluate requirements for M&S

11) Course learning objectives; Mastery of valid M&S requirements for performance specifications in fidelity, resolution, and scope as program life cycles progress. Mastery demonstrated by a grade of 90% correct on a final course exam.

12) Course assessment plan: Projects and Exams

13) Topic list by hour of instruction and reference.

*Competency Level: Understanding*

- i) Hour 1: Introduction and Overview (course notes and syllabus)

*Competency Level: Understanding*

- ii) Hour 2: (Sub ESR P5.1). M&S development and VV&A lifecycle for COTS and GOTS. [1] [2] [3]

*Competency Level: Understanding*

- iii) Hour 3: (Sub ESR P5.1). M&S development and VV&A lifecycle for new development M&S. [1] [3]

*Competency Level: General Awareness*

- iv) Hour 4: (Sub ESR P5.2). The three domains of M&S requirements. [1]

*Competency Level: Understanding*

- v) Hour 5: (Sub ESR P5.3). Representational requirements in M&S and standard methods for capturing them. [1]

*Competency Level: Understanding*

- vi) Hour 6: (Sub ESR P5.3). Representational requirements in M&S and standard methods for capturing them. [1] [3]

*Competency Level: Understanding*

- vii) Hour 7: (Sub ESR P5.4). Conceptual model development and validation

*Competency Level: Understanding*

- viii) Hour 8: (Sub ESR P5.4). Conceptual model development and validation. [1] [3]

*Competency Level: General Awareness*

- ix) Hour 9: (Sub ESR P5.5). M&S process differences between legacy (no, minor & major modifications) and new development models. [1]

*Competency Level: Understanding*

- x) Hour 10: (Sub ESR P5.5). M&S process differences between legacy (no, minor & major modifications) and new development models. [1]

*Competency Level: General Awareness*

- xi) Hour 11: (Sub ESR P5.6). Work products available in M&S development and their role in VV&A. [1] [3] [4]

*Competency Level: Understanding*

- xii) Hour 12: (Sub ESR P5.6). Work products available in M&S development and their role in VV&A. [1] [3] [4]

*Competency Level: Understanding*

- xiii) Hour 13: (Sub ESR P5.7). Changes in M&S fidelity, resolution, and scope across the acquisition lifecycle. [1] [2] [3]

*Competency Level: Understanding*

- xiv) Hour 14: (Sub ESR P5.7). Changes M&S fidelity, resolution, and scope across the acquisition lifecycle. [1] [2] [3]

*Competency Level: Understanding*

- xv) Hour 15: (Sub ESR P5.8). Acceptability criteria in the VV&A process. [1] [3]

*Competency Level: Application*

- xvi) Hour 16: (Sub ESR P5.8). Acceptability criteria in the VV&A process and its relationship to M&S requirements. [1] [3]

*Competency Level: Application*

- xvii) Hour 17: (Sub ESR P5.9). M&S Selection Project. [1] [3]

*Competency Level: Application*

- xviii) Hour 18: (Sub ESR P5.9). M&S Selection Project. [1] [3]

*Competency Level: Mastery*

- xix) Hour 19: (Sub ESR P5.9). M&S Selection Project. [1] [3]

*Competency Level: Application*

- xx) Hour 20: (Sub ESR P5.10). M&S Requirements Development and Evaluation Project [1] [3]

*Competency Level: Application*

- xxi) Hour 21: (Sub ESR P5.10). M&S Requirements Development and Evaluation Project. [1] [3]

*Competency Level: Mastery*

- xxii) Hour 22: (Sub ESR P5.10). M&S Requirements Development and Evaluation Project. [1] [3]

*Competency Level: Mastery*

- xxiii) Hour 23: (Sub ESR P5.10). M&S Requirements Development and Evaluation Project. [1] [3]

*Competency Level: Mastery*

xxiv) Hour 24: (Sub ESR P5.10). M&S Requirements Development and Evaluation Project. [1] [3]

14) Proposed references and texts:

[1] Law, A.M., and W.D. Kelton, *Simulation Modeling and Analysis*, Second Edition, McGraw-Hill, Boston, 1991

[2] DoD. 2004. *Defense Acquisition Guidebook*. <https://akss.dau.mil/dag/>

[3] DoD. 2006. *VV&A Recommended Practices Guide*. <http://vva.dmsomil/>

[4] Rubenstein, R. Y., B. Melamel. 1998. *Modern Simulation and Modeling*. John Wiley and Sons, Inc., New York, NY.

- 1) Course Name: Manage and Reuse
- 2) Course coordinator: Marsha Taliaferro-Gillis, Ph.D.  
6596 Main Street  
Gloucester, VA 23061  
(804)694-3173 (Office)  
(804)824-4663 (Cell)  
mtgillis@werneranderson.com
- 3) Course description: Manage and reuse existing models, data, and simulations appropriately and assure that new products developed are designed and prepared for reuse.
- 4) Modules incorporated into Course - P14
- 5) ESRs that the course supports and the corresponding level of mastery.
  - a) Key concepts of M&S reuse, component-based, and distributed simulations  
Competency Level: General Awareness and Understanding
  - b) Characteristics of new simulation development that make reuse more achievable  
Competency Level: General Awareness
  - c) Sources for models that are available for reuse  
Competency Level: General Awareness
  - d) Cost versus the benefit for reuse of legacy simulations  
Competency Level: Understanding and Mastery
  - e) V&V necessary for reuse of a simulation with a new specific use  
Competency Level: General Awareness and Understanding
  - f) Models for reuse from a set of legacy models  
Competency Level: Understanding and Mastery
  - g) Cost effective options considering reuse of legacy simulations and new simulation development  
Competency Level: Understanding and Mastery
- 6) Prerequisites assumed, and corresponding level of mastery: Mastery of College Level Calculus II and Introduction to M&S as demonstrated by a final grade of not less than a B.
- 7) Module maturity: none

8) Number of contact hours and pace contemplated: 3 hours lecture/week for 6 weeks

9) Proposed Delivery modality: face-to-face and/or on-line

10) Module learning objectives:

- P14.1 Understand key concepts for M&S reuse, component-based, and distributed simulations.
- P14.2 Identify characteristics of new simulation development that make reuse more achievable.
- P14.3 Identify sources for models that are available for reuse.
- P14.4 Analyze cost versus benefit for reuse of legacy simulations.
- P14.5 Describe V&V necessary for reuse of a simulation considering a new specific use.
- P14.6 Given a case study and a sample of VV&A report, identify appropriate models for reuse from a set of legacy models.
- P14.7 Given a case study and a sample of VV&A report, determine the most cost effective option considering reuse of legacy simulations and new simulation development.

11) Course learning objectives: Mastery of management and preparation of designs for reuse of existing data, models, and simulations. Mastery to be demonstrated by passing grades of no less than B+ on projects and exams.

12) Course assessment plan: projects, and exams.

13) Topic list by hour of instruction and reference.

*Competency Level: General Awareness*

- 1) Hour 1: (Sub ESR P14.1). Learn the key concepts for M&S reuse, component-based, and distributed simulations. [1]

*Competency Level: Understanding*

- 2) Hour 2: (Sub ESR P14.1). Understand the key concepts for M&S reuse, component-based, and distributed simulations. [1]

*Competency Level: Understanding*

- 3) Hour 3: (Sub ESR P14.1). Understand the key concepts for M&S reuse, component-based, and distributed simulations. [1]

*Competency Level: General Awareness*

- 4) Hour 4: (Sub ESR P14.2). Learn the characteristics of new simulation development that make reuse more achievable. [1]

*Competency Level: General Awareness*

- 5) Hour5: (Sub ESR P14.2). Learn the characteristics of new simulation development that make reuse more achievable. [1]

*Competency Level: General Awareness*

- 6) Hour 6: (Sub ESR P14.3). Learn the sources for models that are available for reuse. [1]

*Competency Level: Understanding*

- 7) Hour 7: (Sub ESR P14.4). Understand the cost versus the benefit for reuse of legacy simulations. [2]

*Competency Level: Mastery*

- 8) Hour 8: (Sub ESR P14.4). Analyze the cost versus the benefit for reuse of legacy simulations
  - Pastor, Oscar. Juan Carlos Molina. 1998, *Model-Driven Architecture in Practice: A Software Production Environment on Conceptual Modeling*. Springer-Verlag. Berlin, Heidelberg.

*Competency Level: Mastery*

- 9) Hour 9: (Sub ESR P14.4). Analyze the cost versus the benefit for reuse of legacy simulations. [2]

*Competency Level: General Awareness*

- 10) Hour 10: (Sub ESR P14.5). Learn the V&V necessary for reuse of a simulation considering a new specific use. [2]

*Competency Level: Understanding*

- 11) Hour 11: (Sub ESR P14.5). Understand the V&V necessary for reuse of a simulation considering a new specific use. [2]

*Competency Level: Understanding*

- 12) Hour 12: (Sub ESR P14.5). Understand the V&V necessary for reuse of a simulation considering a new specific use. [2]

*Competency Level: Understanding*

- 13) Hour 13: (Sub ESR P14.6). Given a case study and a sample of a VV&A report, identify the appropriate models for reuse from a set of legacy models. [2]

*Competency Level: Mastery*

- 14) Hour 14: (Sub ESR P14.6). Given a case study and a sample of a VV&A report, analyze the appropriate models for reuse from a set of legacy models. [2]

*Competency Level: Mastery*

- 15) Hour 15: (Sub ESR P14.6). Given a case study and a sample of a VV&A report, analyze the appropriate models for reuse from a set of legacy models. [2]

*Competency Level: Understanding*

- 16) Hour 16: (Sub ESR P14.7). Given a case study and a sample of a VV&A report, understand the most cost effective option considering reuse of legacy simulations and new simulation development. [3]

*Competency Level: Mastery*

- 17) Hour 17: (Sub ESR P14.7). Given a case study and a sample of a VV&A report, analyze the most cost effective option considering reuse of legacy simulations and new simulation development. [3]

*Competency Level: Mastery*

- 18) Hour 18: (Sub ESR P14.7). Given a case study and a sample of a VV&A report, analyze the most cost effective option considering reuse of legacy simulations and new simulation development. [3]

14) Proposed references and texts:

[1] Rombach, H. D., Victor R. Basili, Richard W. Selby. 1993 *Experimental Software Engineering Issues*. Springer-Verlag. Berlin, Heidelberg.

[2] Pastor, Oscar. Juan Carlos Molina. 1998, *Model-Driven Architecture in Practice: A Software Production Environment on Conceptual Modeling*. Springer-Verlag. Berlin, Heidelberg.

[3] Zeigler, Bernard P., [Tag Gon Kim](#), [Herbert Praehofer](#). 2000. *Theory of Modeling and Simulation*. Academic Press. San Diego CA.



- 1) Course name: Military Platform Systems Engineering
- 2) Course coordinator: Marsha Taliaferro-Gillis, Ph.D.  
6596 Main Street  
Gloucester, VA 23061  
(804)694-3173 (Office)  
(804)824-4663 (Cell)  
mtgillis@werneranderson.com
- 3) Course description: Military Platform Systems Engineering in a broad-based design oriented to an M&S approach for complex platforms that interact with air-land-sea-based hardware systems, command and control systems and combat systems.
- 4) Modules incorporated into Course – E7
- 5) ESRs that the course supports and the corresponding level of mastery.
  - a) Key fundamental theoretical principles in systems engineering  
Competency Level: General Awareness
  - b) Role and benefits of M&S in systems engineering  
Competency Level: *General Awareness and Understanding*
  - c) Key system characteristics of the system and component subsystems of interest  
Competency Level: *General Awareness and Understanding*
  - d) Key elements of the system and component subsystem to be modeled to meet the requirements of the specific use  
Competency Level: *Application and Mastery*
  - e) Effectiveness of simulation tools used to evaluate the performance of the system and components subsystems  
Competency Level: *Application and Mastery*
  - f) Role of component-based and distributed simulation as it applies to the system and component subsystems  
Competency Level: *General Awareness and Understanding*
  - g) Key M&S issues related to interaction of subsystems within a larger system  
Competency Level: *Application and Mastery*
  - h) VV&A implication of using a simulation of a system that is sufficiently different from its intended use  
Competency Level: *Understanding and Mastery*

- i) Sufficient model detail of system and component subsystems to support program milestone decision requirements  
*Competency Level: Understanding and Mastery*
- j) Sufficient model detail of system and component subsystems to support T&E requirements  
*Competency Level: Understanding and Mastery*
- 6) Prerequisites assumed, and corresponding level of mastery: Awareness of issues surrounding military platform development.
- 7) Course maturity: none
- 8) Number of contact hours and pace contemplate: 3 lecture hours/week for 9 weeks
- 9) Proposed Delivery modality: face-to-face or on-line
- 10) Module learning objectives:
  - E7.1 Identify key fundamental theoretical principles in systems engineering
  - E7.2 Describe the role and benefits of M&S in systems engineering
  - E7.3 Given a case study, understand key system characteristics of the system and component subsystems of interest
  - E7.4 Given a case study, identify the key elements of the system and component subsystem to be modeled to meet the requirements of the specific use
  - E7.5 Given a case study, apply or analyze the effectiveness of simulation tools used to evaluate the performance of the system and components subsystems
  - E7.6 Describe the role of component-based and distributed simulation as it applies to the system and component subsystems
  - E7.7 Given a case study, apply or analyze key M&S issues related to interaction of subsystems within a larger system
  - E7.8 Given a case study, analyze the VV&A implication of using a simulation of a system that is sufficiently different from its intended use
  - E7.9 Given a case study, analyze whether the system and component subsystems are modeled in sufficient detail to support program milestone decision requirements
  - E7.10 Given a case study, analyze whether the system and component subsystems are modeled in sufficient detail to support T&E requirements
- 11) Course learning objectives – Mastery of Military Platform Systems Engineering through the use of M&S key system characteristics, knowledge of applicable simulation tools, component base and distributed simulation, correct execution of VV&A, and application of M&S toward decisions supporting program milestones

and T&E. Mastery to be demonstrated by a grade of not less than B+ on quizzes and final project.

12) Course assessment plan: quizzes and final project.

13) Topic list by hour of instruction and reference.

*Competency Level: General Awareness*

- 1) Hour 1: (Sub ESR E7.1). Learn key fundamental theoretical principles in systems engineering. [1]

*Competency Level: General Awareness*

- 2) Hour 2: (Sub ESR E7.1). Learn key fundamental theoretical principles in systems engineering. [1]

*Competency Level: General Awareness*

- 3) Hour 3: (Sub ESR E7.2). Demonstrate knowledge of the role and benefits of M&S in systems engineering. [1]

*Competency Level: Understanding*

- 4) Hour 4: (Sub ESR E7.2). Demonstrate knowledge of the role and benefits of M&S in systems engineering. [1]

*Competency Level: General Awareness*

- 5) Hour 5: (Sub ESR E7.2). Given a case study, review key system characteristics of the system and component subsystems of interest. [1]

*Competency Level: Understanding*

- 6) Hour 6: (Sub ESR 7.3). Given a case study, understand key system characteristics of the system and component subsystems of interest. [1]

*Competency Level: Application*

- 7) Hour 7: (Sub ESR E7.4). Given a case study, demonstrate the key elements of the system and component subsystem to be modeled to meet the requirements of the specific use. [1]

*Competency Level: Application*

- 8) Hour 8: (Sub ESR E7.4). Given a case study, apply the key elements of the system and component subsystem to be modeled to meet the requirements of the specific use. [1]

*Competency Level: Mastery*

- 9) Hour 9: (Sub ESR E7.4). Given a case study, analyze and use the key elements of the system and component subsystem to be modeled to meet the requirements of the specific use. [1]

*Competency Level: Application*

- 10) Hour 10: (Sub ESR E7.5). Given a case study, apply the effectiveness of simulation tools used to evaluate the performance of the system and component subsystems. [1]

*Competency Level: Application*

- 11) Hour 11: (Sub ESR E7.5). Given a case study, apply the effectiveness of simulation tools used to evaluate the performance of the system and component subsystems. [1]

*Competency Level: Mastery*

- xii) Hour 12: (Sub ESR E7.5). Given a case study, analyze the effectiveness of simulation tools used to evaluate the performance of the system and component subsystems. [1]

*Competency Level: General Awareness*

- xiii) Hour 13: (Sub ESR E7.6). Learn the role of component-based and distributed simulation as it applies to the system and component subsystems. [2]

*Competency Level: Understanding*

- xiv) Hour 14: (Sub ESR E7.6). Demonstrate the role of component-based and distributed simulation as it applies to the system and component subsystems. [2]

*Competency Level: Understanding*

- xv) Hour 15: (Sub ESR E7.6). Review the role of component-based and distributed simulation as it applies to the system and component subsystems. [2]

*Competency Level: Application*

- xvi) Hour 16: Sub ESR E7.7). Given a case study, apply key M&S issues related to interaction of subsystems within a larger system. [1]

*Competency Level: Mastery*

- xvii) Hour 17: (Sub ESR E7.7). Given a case study, analyze key M&S issues related to interaction of subsystems within a larger system. [1]

*Competency Level: Understanding*

- xviii) Hour 18: (Sub ESR E7.8). Given a case study, demonstrate the VV&A implication of using a simulation of a system that is sufficiently different from its intended use. [1]

*Competency Level: Mastery*

- xix) Hour 19: (Sub ESR E7.8). Given a case study, analyze the VV&A implication of using a simulation of a system that is sufficiently different from its intended use. [1]

*Competency Level: Mastery*

- xx) Hour 20: (Sub ESR E7.8). Given a case study, analyze the VV&A implication of using a simulation of a system that is sufficiently different from its intended use. [1]

*Competency Level: Understanding*

- xxi) Hour 21: (Sub ESR E7.9). Given a case study, demonstrate whether the system and component subsystems are modeled in sufficient detail to support program milestone decision requirements. [1]

*Competency Level: Mastery*

- xxii) Hour 22: (Sub ESR E7.9). Given a case study, analyze whether the system and component subsystems are modeled in sufficient detail to support program milestone decision requirements. [1]

*Competency Level: Mastery*

- xxiii) Hour 23: (Sub ESR E7.9). Given a case study, analyze whether the system and component subsystems are modeled in sufficient detail to support program milestone decision requirements. [3]

*Competency Level: Understanding*

- xxiv) Hour 24: (Sub ESR E7.10). Given a case study, demonstrate whether the system and component subsystems are modeled in sufficient detail to support T&E requirements. [4]

*Competency Level: Mastery*

- xxv) Hour 25: (Sub ESR E7.10). Given a case study, analyze whether the system and component subsystems are modeled in sufficient detail to support T&E requirements. [4]

*Competency Level: Mastery*

- xxvi) Hour 26: (Sub ESR E7.10). Given a case study, analyze whether the system and component subsystems are modeled in sufficient detail to support T&E requirements. [4]

*Competency Level: Mastery*

- xxvii) Hour 27: (Sub ESR E7.10). Given a case study, analyze whether the system and component subsystems are modeled in sufficient detail to support T&E requirements. [4]

14) Proposed references and texts:

- [1] Kossiakoff, Alexander; William N. Sweet. *Systems Engineering Principles and Practice*. Hoboken, NJ: John Wiley and Sons. 2003.
- [2] Kelton, W., A. Law. 2000. *Simulation Modeling and Analysis*, Boston, MA.
- [3] Bartolomei, Jason E. The Use of Systems Engineering Processes and Tools to Develop a System Dynamic Simulation Model of Engineering Support During the Development Phase of an Acquisition Program. Air Force Institute of Technology, Wright-Patterson Air Force Base, OH School Of Engineering: 2001.
- [4] Test & Evaluation Management Guide, Fifth Edition. Fort Belvoir, VA: Defense Acquisition University Press: 2005.
- [5] Sarjoughian, Hessam S. & Francois E. Cellier. *Discrete Event Modeling and Simulation Technologies: A Tapestry of Systems and AI-Based Theories and Methodologies*. New York: Springer-Verlag. 2001.
- [6] VV&A Recommended Practices Guide

- 1) Course name: Operational Models
- 2) Module coordinator: Marsha Taliaferro-Gillis, Ph.D.  
6596 Main Street  
Gloucester, VA 23061  
(804)694-3173 (Office)  
(804)824-4663 (Cell)  
mtgillis@werneranderson.com
- 3) Course description: Properties of a representative suite of operational models across the services. including the difference in data requirements at different levels of abstraction; the levels of detail included in operational analyses; and assessment of the effectiveness of a sample suite of operational models in evaluating the system, engagement, mission and campaign of operational requirements
- 4) Modules incorporated into Course - O2
- 5) ESRs that the course supports and the corresponding level of mastery.
  - a) Identification for levels of detail needed for operational analysis and simulation model development life cycle.  
*Competency Level: General Awareness*
  - b) Identification of prospective operational models from a list.  
*Competency Level: General Awareness*
  - c) Clarification of operational analyses included in engagement, mission and campaign systems.  
*Competency Level: General Awareness*
  - d) Demonstration of the role of aggregation and disaggregation in operational levels.  
*Competency Level: General Awareness and Understanding*
  - e) Comprehend the importance of developing quantifiable metrics of performance to affordability of mission requirements.  
*Competency Level: General Awareness and Understanding*
  - f) Understand different levels of abstraction in data requirements.  
*Competency Level: General Awareness and Understanding*
  - g) Description of the role of modeling inputs and assumptions in developing operational analysis across all missions, functions and objectives.  
*Competency Level: General Awareness*

- h) Review basic probability and statistics and sensitivity analysis of critical assumptions for solution outputs.  
*Competency Level: General Awareness and Understanding*
- i) Application of operational models in evaluating reliability and effectiveness to test in a net-centric environment at multiple levels.  
*Competency Level: Application and Mastery*
- 6) Prerequisites assumed, and corresponding level of mastery. Mastery of Introductory College Level of M&S as demonstrated by a final grade of no less than a B.
- 7) Course maturity: none
- 8) Number of contact hours and pace contemplated: 3 hours lecture/week for 5 weeks.
- 9) Proposed delivery modality: face-to-face and/or online.
- 10) Module learning objectives:
  - O2.1 Identify levels of detail typically included operational analyses (e.g., system, engagement, mission, campaign)
  - O2.2 Identify prospective operational models from a list of models.
  - O2.3 Identify levels of detail typically included in operational analyses.
  - O2.4 Understand the role of aggregation and disaggregation across operational levels of detail.
  - O2.5 Understand the importance of developing quantifiable metrics of performance to meet mission requirements affordably.
  - O2.6 Understand the difference in data requirements at different levels of abstraction
  - O2.7 Describe the role of modeling inputs and assumptions in developing operational analysis (scenario & threat, missions, alternatives, required input data, operations concept, basing & deployment, support concept, [MAIS AoA: organizational missions, functions, & objectives]).
  - O2.8 Understand the importance of sensitivity analysis of critical assumptions in determine solution outputs.
  - O2.9 Given a case study, assess the effectiveness of a sample suite of operational models in evaluating the full range of operational requirements (reliability, effectiveness, logistics footprint, supportability).
- 11) Course learning objectives: Mastery in evaluating operational models, understanding the role of aggregation and disaggregation in operational levels; identify levels of detail, prospective operational models and roles of model inputs and assumptions. Mastery is to be demonstrated by a grade of no less than 85% correct on a final examination of 50 multiple choice questions.
- 12) Course assessment plan: final exam in a multiple choice format



13) Topic list by hour of instruction and reference:

*Competency Level: General Awareness*

- i) Hour 1: (Sub ESR O2.1). Learn the levels of detail typically included in operational analyses [1] [2]

*Competency Level: General Awareness*

- ii) Hour 2: (Sub ESR O2.2). Review prospective operational models from a list of models. [1]

- Model library to develop list of models

*Competency Level: General Awareness*

- iii) Hour 3: (Sub ESR O2.3). Analysis of levels of detail typically included in system, engagement, mission, and campaign. [1]

*Competency Level: General Awareness*

- iv) Hour 4: (Sub ESR O2.4). Learn the role of aggregation and disaggregation across operational levels of detail. [3]

*Competency Level: Understanding*

- v) Hour 5: (Sub ESR O2.4). Use the role of aggregation and disaggregation across operational levels of detail. [3]

*Competency Level: General Awareness*

- vi) Hour 6: (Sub ESR O2.5). Learn the importance of developing quantifiable metrics of performance to meet mission requirements affordably. [3]

*Competency Level: Understanding*

- vii) Hour 7: (Sub ESR O2.5). Demonstration of the importance of developing quantifiable metrics of performance to meet mission requirements affordably. [3]

*Competency Level: General Awareness*

- viii) Hour 8: (Sub ESR O2.6). Review the difference in data requirements at different levels of abstraction [3]

*Competency Level: Understanding*

- ix) Hour 9: (Sub ESR O2.6). Demonstration of the difference in data requirements at different levels of abstraction [3]

x)

*Competency Level: General Awareness*

- xi) Hour 10: (Sub ESR O2.7). Review the role of modeling inputs and assumptions in developing operational analysis (scenario & threat, missions, alternatives, required input data, operations concept, basing & deployment, support concept, [MAIS AoA: organizational missions, functions, & objectives]). [4]

*Competency Level: General Awareness*

- xii) Hour 11: (Sub ESR O2.7). Learn the role of modeling inputs and assumptions in developing operational analysis (scenario & threat, missions, alternatives, required input data, operations concept, basing & deployment, support concept, [MAIS AoA: organizational missions, functions, & objectives]). [3]

*Competency Level: General Awareness*

- xiii) Hour 12: (Sub ESR O2.8). Learn the importance of sensitivity analysis of critical assumptions in determining solution outputs. [1]

*Competency Level: Understanding*

- xiv) Hour 13: (Sub ESR O2.8). Demonstration of the importance of sensitivity analysis of critical assumptions in determining solution outputs for operations. [4]

*Competency Level: Application*

- xv) Hour 14: (Sub ESR O2.9). Application of the effectiveness of a sample suite of operational models in evaluating the full range of operational requirements (reliability, effectiveness, operational footprint, supportability criteria etc.) to sustain the mission on long term. [5]

*Competency Level: Mastery*

- xvi) Hour 15: (Sub ESR O2.9). Analysis of the effectiveness of a sample suite of operational models in evaluating the full range of operational requirements (reliability, effectiveness, logistics footprint, supportability criteria, etc.) to sustain the mission on long term. [5]

14) Proposed references and texts:

[1] Kelton, W., A. Law. 2000. *Simulation Modeling and Analysis*, 3rd ed. McGraw-Hill, Boston, MA.

[2] Mackenzie, G., G. Schulmeyer, L. Yilmaz. 2002. *Verification Technology Potential with Different Modeling and Simulation Development and Implementation Paradigms*. Working paper, John Hopkins University Applied Physics Laboratory, Laurel, Maryland.

[3] Kress, M. 2002. *Operational Logistics: The Art and Science of Sustaining Military Operations*, 1st ed. Springer, Norwell, MA.

[4] Altioik, T., B. Melamed. 2007. *Simulation Modeling and Analysis with ARENA*, Academic Press, Burlington, MA.

[5] Hammonds, P., B. Zeigler. 2007. *Modeling and Simulation - Based Data Engineering: Introducing Pragmatics into Ontologies for Net-Centric Information Exchange*, Burlington, MA.

- 1) Course name: The Environment as an Interactive System
- 2) Module coordinator: Marsha Taliaferro-Gillis, Ph.D.  
6596 Main Street  
Gloucester, VA 23061  
(804)694-3173 (Office)  
(804)824-4663 (Cell)  
mtgillis@werneranderson.com
- 3) Course description: The fundamentals of terrestrial science (geology, oceanography, meteorology, and near-earth space science) and the influences and interactions of representative systems with the terrestrial environment.
- 4) Modules incorporated into Course: - E12
- 5) ESRs that the Course supports and corresponding level of mastery:
  - a) Fundamental theoretical principles of terrestrial science  
Competency Level: General Awareness, Understanding, and Application
  - b) Key characteristics of a system of interest  
Competency Level: General Awareness, Understanding and Application
  - c) Key elements of modeled environments and requirements of specific use  
Competency Level: General Awareness
  - d) Application and analysis of effectiveness of simulation tools used for evaluating the environmental system of interest  
Competency Level: General Awareness, Understanding, Application, & Mastery
  - e) Application and analysis of key M&S issues related to a system of interest within the environment  
Competency Level: General Awareness, Understanding, Application & Mastery
  - f) Analysis of 'VV&A implications used in a simulation of an environment different from the intended use.  
Competency Level: Mastery
  - g) Analysis of detailed environmental factors to support program milestone decision requirements  
Competency Level: Mastery
  - h) Analysis of sufficiency of detailed environmental factors for supporting T&E requirements  
Competency Level: Mastery

- 6) Prerequisites assumed, and corresponding level of mastery: Mastery of an introductory course to terrestrial science with a passing grade of not less than a B
- 7) Course maturity: none
- 8) Number of contact hours and pace contemplated: 3 hour lecture/week for 9 weeks
- 9) Proposed Delivery modality: face-to-face, on-line, VTC, resident, customer's site
- 10) Module learning objectives:
  - E12.1 Given a case study, understand key fundamental theoretical principles in terrestrial science as they apply to the system of interest.
  - E12.2 Given a case study, understand key system characteristics of the system of interest.
  - E12.3 Given a case study, identify the key elements of the environment to be modeled to meet the requirements of the specific use.
  - E12.4 Given a case study, apply or analyze the effectiveness of simulation tools used evaluate the performance of the system of interest in the environment.
  - E12.5 Given a case study, apply or analyze key M&S issues related to interaction of the system of interest with the environment (terrain database compatibility, line-of-sight, weather,).
  - E12.6 Given a case study, analyze the VV&A implications of using a simulation in an environment that is sufficiently different from its intended use.
  - E12.7 Given a case study, analyze if the environmental factors are modeled in sufficient detail to support program milestone decision requirements.
  - E12.8 Given a case study, analyze if the environmental factors are modeled in sufficient detail to support T&E requirements.
- 11) Course learning objectives: Mastery of the fundamentals of terrestrial science and the interactions of geology, oceanography, meteorology, and near-earth space science with detailed environmental factors in a system of interest as demonstrated by a passing grade of 85% correct on final course exam in a multiple choice format.
- 12).Course assessment plan: Application project and final exam in a multiple choice format
- 13) Topic list by hour of instruction and reference.

*Competency Level: General Awareness*

- i. Hour 1: (Sub ESR E12.1). Review of the key fundamental theoretical principles in terrestrial science as they apply to a system of interest. [1] [2] [3] [4] [5] [6]

*Competency Level: Understanding*

- ii. Hour 2: (Sub ESR E12.1). Comprehend key fundamental theoretical principles in terrestrial science as they apply to a system of interest. [1] [2] [3] [4] [5] [6]

*Competency Level: Application*

- iii. Hour 3: (Sub ESR E12.1). Given a case study apply key fundamental theoretical principles in terrestrial science as they apply to the system of interest. [1] [2] [3] [4] [5] [6]

*Competency Level: General Awareness*

- iv. Hour 4: (Sub ESR E12.2). Describe key system characteristics of the system of interest [1] [7]

*Competency Level: Understanding*

- v. Hour 5: (Sub ESR E12.2). Understand key system characteristics of the system of interest [1] [7]

*Competency Level: General Awareness*

- vi. Hour 6: (Sub ESR E12.3). Identify the key elements of the environment to be modeled to meet the requirements of the specific use. [8] [9] [10] [11] [12] [13] [14] [15] [16]

*Competency Level: General Awareness*

- vii. Hour 7: (Sub ESR E12.3). Identify the key elements of the environment to be modeled to meet the requirements of the specific use. [8] [9] [10] [11] [12] [13] [14] [15] [16]

*Competency Level: General Awareness and Application*

- viii. Hour 8: (Sub ESR E12.4). Describe and demonstrate the effectiveness of simulation tools used to evaluate the performance of the system of interest in the environment. [17] [18] [19]

*Competency Level: Understanding*

- ix. Hour 9: (Sub ESR E12.4). Given a case study, apply or analyze the effectiveness of simulation tools used to evaluate the performance of the system of interest in the environment. [17] [18] [19]

*Competency Level: Application*

- x. Hour 10: (Sub ESR E12.4). Given a case study, apply or analyze the effectiveness of simulation tools used to evaluate the performance of the system of interest in the environment. [17] [18] [19]

*Competency Level: Application*

- xi. Hour 11: (Sub ESR E12.4). Given a case study, apply or analyze the effectiveness of simulation tools used to evaluate the performance of the system of interest in the environment. [17] [18] [19]

*Competency Level: Mastery*

- xii. Hour 12: (Sub ESR E12.4). Given a case study, apply or analyze the effectiveness of simulation tools used to evaluate the performance of the system of interest in the environment. [17] [18] [19]

*Competency Level: General Awareness*

- xiii. Hour 13: (Sub ESR E12.5). Given a case study, apply or analyze key M&S issues related to interaction of the system of interest with the environment (terrain database compatibility, line-of-sight, weather,). [2] [5] [19] [20] [6]

*Competency Level: Understanding*

- xiv. Hour 14: (Sub ESR E12.5). Given a case study, apply or analyze key M&S issues related to interaction of the system of interest with the environment (terrain database compatibility, line-of-sight, weather,). [2] [5] [19] [20] [6]

*Competency Level: Application*

- xv. Hour 15: (Sub ESR E12.5). Given a case study, apply or analyze key M&S issues related to interaction of the system of interest with the environment (terrain database compatibility, line-of-sight, weather,). [2] [5] [19] [20] [6]

*Competency Level: Application*

- xvi. Hour 16: (Sub ESR E12.5). Given a case study, apply or analyze key M&S issues related to interaction of the system of interest with the environment (terrain database compatibility, line-of-sight, weather,). [2] [5] [19] [20] [6]

*Competency Level: Mastery*

- xvii. Hour 17: (Sub ESR E12.5). Given a case study, apply or analyze key M&S issues related to interaction of the system of interest with the environment (terrain database compatibility, line-of-sight, weather,). [2] [5] [19] [20] [6]

*Competency Level: Mastery*

- xviii. Hour 18: (Sub ESR E12.6). Given a case study, analyze the VV&A implications of using a simulation in an environment that is sufficiently different from its intended use. [17] [21]

*Competency Level: Mastery*

- xix. Hour 19: (Sub ESR E12.6). Given a case study, analyze the VV&A implications of using a simulation in an environment that is sufficiently different from its intended use. [17] [21]

*Competency Level: Mastery*

- xx. Hour 20: (Sub ESR E12.6). Given a case study, analyze the VV&A implications of using a simulation in an environment that is sufficiently different from its intended use. [17] [21]

*Competency Level: Mastery*

- xxi. Hour 21: (Sub ESR E12.7). Given a case study, analyze if the environmental factors are modeled in sufficient detail to support program milestone decision requirements. [22] [23] [24]

*Competency Level: Mastery*

- xxii. Hour 22: (Sub ESR E12.7). Given a case study, analyze if the environmental factors are modeled in sufficient detail to support program milestone decision requirements. [22] [23] [24]

*Competency Level: Mastery*

- xxiii. Hour 23: (Sub ESR E12.7). Given a case study, analyze if the environmental factors are modeled in sufficient detail to support program milestone decision requirements. [22] [23] [24]

*Competency Level: Mastery*

- xxiv. Hour 24: (Sub ESR E12.8). Given a case study, analyze if the environmental factors are modeled in sufficient detail to support T&E requirements. [24] [25] [26]

*Competency Level: Mastery*

- xxv. Hour 25: (Sub ESR E12.8). Given a case study, analyze if the environmental factors are modeled in sufficient detail to support T&E requirements. [24] [25] [26]

*Competency Level: Mastery*

- xxvi. Hour 26: (Sub ESR E12.8). Given a case study, analyze if the environmental factors are modeled in sufficient detail to support T&E requirements. [24] [25] [26]

*Competency Level: Mastery*

- xxvii. Hour 27: (Sub ESR E12.8). Given a case study, analyze if the environmental factors are modeled in sufficient detail to support T&E requirements. [24] [25] [26]

14) Proposed references and texts:

[1] Atmospheric Science Department, UAH Courses. Retrieved October 23, 2007 from [http://www.nsstc.uah.edu/atmos/course\\_description\\_undergrad.html](http://www.nsstc.uah.edu/atmos/course_description_undergrad.html)



- [2] Hargreaves, John. Keith..1992. *The Solar Terrestrial Environment: An Introduction to Geospace—Science*. Cambridge University Press. ISBN 0521427371
- [3] National Geophysical Data Center (NGDC). Solar Data Services. Retrieved October 23, 2007 from <http://www.ngdc.noaa.gov/stp/SOLAR/solar.html>.
- [4] National Geophysical Data Center (NGDC). Welcome to SPIDR. Retrieved October 23, 2007 from <http://spidr.ngdc.noaa.gov/spidr/index.jsp>.
- [5] SAIC: Space: Space, Earth, and Atmospheric Sciences. Retrieved October 23, 2007 from <http://www.saic.com/space/earth.html>.
- [6] Twicken, Joe. Fundamentals of Atmospheres, Weather and Climate. Retrieved October 23, 2007 from [http://resources.yesican-science.ca/trek/mars/lander/mgs\\_atmos10.htm](http://resources.yesican-science.ca/trek/mars/lander/mgs_atmos10.htm).
- [7] JSIMS Terrain Common Data Model, Revision 1.2a 27 July, 2007 Prepared by Lockheed Martin Information Systems Bellvue, WA. The MITRE Corporation McLean, VA, SAIC, Orlando, FL
- [8] National Geophysical Data Center (NGDC). Earth Observation Group. Retrieved October 23, 2007 from <http://www.ngdc.noaa.gov/dmsp/>
- [9] National Geophysical Data Center (NGDC). Geomagnetism. Retrieved October 23, 2007 from <http://www.ngdc.noaa.gov/seg/geomag/geomag.shtml>.
- [10] National Geophysical Data Center (NGDC). GOES Solar X-ray Imager. Retrieved October 23, 2007 from <http://sxi.ngdc.noaa.gov>
- [11] National Geophysical Data Center (NGDC). GOES Space Environment Monitor, Retrieved October 23, 2007 from <http://www/ngdc/noaa.gov/stp/GOES/goes.html>.
- [12] National Geophysical Data Center (NGDC). Ionosphere Data Archived at NGDC. Retrieved October 23, 2007 from <http://www.ngdc.noaa.gov/stp/IONO/ionohome.html>.
- [13] National Geophysical Data Center (NGDC). Land Geophysics. Retrieved October 23, 2007 from <http://www.ngdc.noaa.gov/seg/>
- [14] National Geophysical Data Center (NGDC). Links to Educational Resources in Oceanography and Earth Sciences. Retrieved October 23, 2007 from <http://www/ngdc.noaa.gov/mgg/education.html>.

- [15] National Geophysical Data Center (NGDC). Natural Hazards Data. Retrieved October 23, 2007 from <http://www.ngdc.noaa.gov/seg/hazard/hazards.shtml>
- [16] National Geophysical Data Center (NGDC). NOAA/POES Space Environment Monitor. Retrieved October 23, 2007 from [http://www.ngdc.noaa.gov/stp/NOAA/noaa\\_poes.html](http://www.ngdc.noaa.gov/stp/NOAA/noaa_poes.html).
- [17] Argent, Robert (2005). A Case Study of Environmental Modeling and Simulation Using Transplantable Components. *Environmental Modeling & Software*, 20(12), 1514-1523 Retrieved November 1, 2007 from [http://www.sciencedirect.com/science?\\_ob=ArticleURL&\\_udi=B6VHC-4GSBFSH-2&\\_...](http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6VHC-4GSBFSH-2&_...)
- [18] Miller, Dale K., Kent Cauble, David Bakeman, Lockheed Martin Information Systems Advanced Simulation 3605 132<sup>nd</sup> Ave. SE, Suite 400, Bellvue, WA. 98—6, Center, Mark Torpey, Bill Helfinistine, Lockheed Martin Information Systems Advanced Simulation Center, 164 Middlesex Turnpike, Burlington, MA., Andy Ceranowicz, Alion Science and Technology, P. O. Box 72, Stow. MA 01775, Extensions to the CTDB Format to Support Joint Experimentation. Retrieved from [ddmiller@lads.is.lmco.com](mailto:ddmiller@lads.is.lmco.com), [kcauble@lads.is.lmco.com](mailto:kcauble@lads.is.lmco.com), [dbakeman@lads.is.lmco.com](mailto:dbakeman@lads.is.lmco.com), [mtorpey@lads.is.lmc.ocom](mailto:mtorpey@lads.is.lmc.ocom), [bhelf@lads.is.lmco.com](mailto:bhelf@lads.is.lmco.com), [aceranowicz@alionscience.com](mailto:aceranowicz@alionscience.com).
- [19] Stevens, Clark D.(2000). Toward a Common Synthetic Natural Environment. Retrieved October 23, 2007 from [file:///C:/Documents and Settings/mtgillis/Desktop/htmlSNE\\_SRTM\\_Precision\\_Data.html](file:///C:/Documents and Settings/mtgillis/Desktop/htmlSNE_SRTM_Precision_Data.html).
- [20] Triangulated Irregular Network (TIN) Tutorial. Retrieved October 23, 2007 from [file:///C:/Documents and Settings/mtgillis/Desktop/htmlSNE\\_TIN/html](file:///C:/Documents and Settings/mtgillis/Desktop/htmlSNE_TIN/html)
- [21] Foundations for Verification and Validation of the Natural Environment in a Simulation. 2004. Retrieved October 23, 2007 from [wa.dmsomil/Special topics/Environment/environment.hrm](http://wa.dmsomil/Special topics/Environment/environment.hrm)
- [22] Stevens, Clark D., Brett Butler, Charles Campbell, Jon Watkins, Eric Root, Henry Marshall, Teresita Sotomayor. A Common Runtime Format for Virtual and Constructive Simulations. Retrieved October 23, 2007 from [file:///C:/Documents and Settings/mtgillis/Desktop/htmlSNE\\_SRTM\\_Precision\\_Data.html](file:///C:/Documents and Settings/mtgillis/Desktop/htmlSNE_SRTM_Precision_Data.html).
- [23] Stevens, Clark D., Dale D., Miller, Steve Prager, Charles Campbell, Jon Watkins, Eric Root, James Oneal. Data Modeling Implications for a Data Driven Environmental Software Sub-System. Retrieved October 23, 2007 from [file:///C:/Documents and Settings/mtgillis/Desktop/htmlSNE\\_SRTM\\_Precision\\_Data.html](file:///C:/Documents and Settings/mtgillis/Desktop/htmlSNE_SRTM_Precision_Data.html).

[24] Best Practices – Modeling and Simulation Verification, Validation and Accreditation (VV&A) Guidebook. Retrieved October 23, 2007 from [http://www.drdc.gc.ca/seco/documents/VVA\\_Guidebookk\\_DND\\_SECO\\_May\\_2003\\_e.html](http://www.drdc.gc.ca/seco/documents/VVA_Guidebookk_DND_SECO_May_2003_e.html).

[25] Richbourg, Robert, Institute for Defense Analysis. Digital Elevation Model Resolution and Simulated Natural Environment Terrain Representation Fidelity. Retrieved November 1, 2007 from [www.sisostds.org/index.php?tg=articles&idx+More&article=45&article203-24k](http://www.sisostds.org/index.php?tg=articles&idx+More&article=45&article203-24k)

[26] Final Precision Data Product Descriptions. Retrieved October 23, 2007 from [file:///C:/Documents and Settings/mtgillis/Desktop/htmlSNE\\_SRTM\\_Precision\\_Data.html](file:///C:/Documents%20and%20Settings/mtgillis/Desktop/htmlSNE_SRTM_Precision_Data.html).

## George Mason University

- 1) Course name: M&S in the Acquisition Process, Part 1
- 2) Course coordinator / point of contact and contact information  
Jim Campbell, GMU, [jcampbell@alionscience.com](mailto:jcampbell@alionscience.com), 703-933-3356
- 3) Course description: At the completion of this course, students will be able to describe the Pre-Acquisition M&S activities, and the M&S used in the initial phases of the Acquisition Life Cycle, using the progression of different modeling and simulation applications in use in each phase as a benchmark. They will be able to identify a particular tool and apply it appropriately to the correct point in the lifecycle and relate specific tools to the decision points that separate the acquisition phases. This course is presented at the application level. For courses at the understanding or general awareness level, time can be reduced and practical application periods deleted.
- 4) Modules incorporated into Course This course incorporates ESRs A1, A2, P1, and P9.
- 5) ESRs that the course supports This course incorporates ESRs A1 (Describe the types, role and value of formal Modeling and Simulations, and their various characterizations for application to systems management, particularly with regard to design, testing, training, production, cost estimation, manning, and logistical simulations.); A2 (Understand the critical decisions in the acquisition lifecycle and how/what M&S is used to inform those decisions in order to reduce the time resources and risk associated with the acquisition process.); P1 (Describe the role of modeling and simulation prior to the concept decision to identify and quantify capability gaps and to estimate how well new program concepts might address those gaps.); and P9 (Know models and simulations used in a given phase of the acquisition process, their inputs and outputs, and their capabilities and limitations.).
- 6) Prerequisites: ACQ 101, ACQ 201, Essentials of Modeling and Simulation (MSCO on line orientation: <http://ems.dmsoc.mil/>)
- 7) Course maturity: Some of the course material is presently taught in a different format in the GMU CPE course and in the MSIAC MSSOC.
- 8) Number of contact hours and pace contemplated 24 hours, 1 three-day session
- 9) Proposed Delivery face-to-face, or VTC; resident, or customer's site
- 10) Proposed references and texts:
  - a) Acquisition M&S Course Bibliography:
    - i) Committee on Modeling and Simulation for Defense Transformation, National Research Council. Defense Modeling, Simulation, and Analysis:

Meeting the Challenge. Washington, D.C.: The National Academies Press, 2006.

- ii) Committee on Modeling and Simulation Enhancements for 21<sup>st</sup> Century Manufacturing and Defense Acquisition, National Research Council. Modeling and Simulation in Manufacturing and Defense Acquisition: Pathways to Success. Washington, D.C.: The National Academies Press, 2002.
  - iii) Computer Science and Telecommunications Board. Modeling and Simulation: Linking Entertainment and Defense. Washington, D.C.: The National Academies Press, 1997.
  - iv) Johnson, Michael V.R., McKeon, Mark F., and Szanto, Terrence R. Simulation Based Acquisition: A New Approach. Fort Belvoir, VA: Defense Systems Management College Press, 1998.
  - v) Sabbagh, Karl. Twenty-First-Century Jet: The Making and Marketing of the Boeing 777. New York: Scribner. 1996.
  - vi) Schrage, Michael. Serious Play: How the World's Best Companies Simulate to Innovate. Boston: Harvard Business School Press. 2000.
- b) Publications and Regulations
- i) DoD Directive 5000.1, Defense Acquisition System, 12 May 2003
  - ii) DoD Instruction 5000.2, Operation of the Defense Acquisition System, 12 May 2003
  - iii) DoD Directive 5000.59, DoD Modeling and Simulation (M&S) Management, 8 August 2007
  - iv) DoD Instruction 5000.61, DoD Modeling and Simulation (M&S) Verification, Validation, and Accreditation (VV&A), 13 May 2003
  - v) Defense Acquisition Guidebook, Version 1.0, 17 October 2004
- c) Joint Chiefs
- i) CJCSI 3170.01F, Joint Capabilities Integration and Development System, 1 May 2007
  - ii) CJCSM 3170.01C, Operation of the Joint Capabilities Integration and Development system, 1 May 2007

d) Services

- i) AR 70-1, Army Acquisition Policy, 31 December 2003
- ii) AR 5-11, Management of Army Models & Simulations, 1 February 2005
- iii) DA PAM 5-11, Verification, Validation and Accreditation of Army Models and Simulations, 30 September 1999
- iv) DA PAM 5-12, Simulation Support Planning and Plans, 2 March 2005
- v) DA Pam 70-3, Army Acquisition Procedures, 15 July 1999
- vi) SECNAVINST 5000.2C, [Operation of the Defense Acquisition System], 19 November 2004
- vii) SECNAVINST 5200.38A, Department Of The Navy Modeling And Simulation Program, 28 February 2002
- viii) OPNAVINST 5200.34, Navy Modeling and Simulation (M&S) Management, 28 May 2002
- ix) DON M&S VV&A Implementation Handbook, Volume I VV&A Framework, 30 March 2004
- x) AFRPD 63-1 Capabilities-Based Acquisition System, 10 July 2003
- xi) AFI 63-101, Operations Of Capabilities Based Acquisition System, 29 July 2005
- xii) AFRPD 16-10 Modeling And Simulation (M&S) Management, 30 January 1995
- xiii) AFI 16-1002, Modeling and Simulation (M&S) Support to Acquisition, 1 June 2000
- xiv) Department of Defense Acquisition Modeling and Simulation Master Plan, 17 April, 2006

11) Course learning objectives:

- a) A1.1: List the three types of models
- b) A1.2: Describe the purpose and characteristics of each type of model
- c) A1.3: List the three types of simulations
- d) A1.4: Describe the purpose and characteristics of each type of simulation
- e) A1.5: Describe how M&S is used in systems design

- f) A1.9: Describe how M&S is used in systems cost estimation
- g) A1.10: Describe how M&S is used in systems manpower integration
- h) A2.1: Identify the six critical decisions in the acquisition lifecycle.
- i) A2.2: Describe primary and secondary types of M&S functions that support each critical decision.
- j) A2.3: Identify the intended use of each type of M&S supporting the six critical decisions.
- k) A2.4: Identify representative examples of each type of M&S supporting the six critical decisions.
- l) P1.1: Describe the JCIDS process prior to the Concept Decision.
- m) P1.2: Identify the three types of Functional Analyses.
- n) P1.3: Describe how M&S is used in each level of Functional Analysis.
- o) P1.4: Identify the components of DOTMLPF.
- p) P1.5: Describe how M&S is used for DOTMLPF determinations.
- q) P9.1: Identify the five phases of the acquisition life cycle.
- r) P9.2: Identify the principal M&S applications used in each of the five phases of the acquisition life cycle.
- s) P9.3: Describe representative examples of M&S used for each type of application in each phase of the acquisition life cycle.
- t) P9.4: List the inputs, outputs, capabilities and limitations of each example M&S.

12) Course assessment plan: Examination, quiz, and practical exercise.

13) Topic list by hour of instruction and reference. For example:

- 1) Hour one: Overview And Orientation (course notes and syllabus) A1.1- A1.4
- 2) Hour two: Overview And Orientation (course notes and syllabus) A1.1- A1.4 A2.1- P9.1
- 3) Hour three: M&S in support of the Concept Decision (course notes and syllabus) A2.2-4
- 4) Hour four: Functional Analyses I (course notes and syllabus) P1.1-3
- 5) Hour five: Functional Analyses II (course notes and syllabus) P1.1-3
- 6) Hour six: DOTMLPF considerations (course notes and syllabus) P1.4, P1.5
- 7) Hour seven: Practical application (course notes and syllabus) P1 all
- 8) Hour eight: Quiz and review
- 9) Hour nine: M&S in Concept Refinement (course notes and syllabus) P9.2-4
- 10) Hour ten: M&S in support of the Milestone A Decision (course notes and syllabus) A2.2-4
- 11) Hour eleven: M&S in system cost estimation and MANPRINT (course notes and syllabus) A1.9-10
- 12) Hour twelve: Practical application Concept Refinement Phase(course notes and syllabus)
- 13) Hour thirteen: Practical application Concept Refinement Phase(course notes and syllabus)
- 14) Hour fourteen: M&S in Technology Development (course notes and syllabus) P9.2-4

- 15) Hour fifteen: M&S in support of the Milestone B Decision (course notes and syllabus) A2.2-4
- 16) Hour sixteen: M&S in system design (course notes and syllabus) A1.5
- 17) Hour seventeen: Practical application Technology Development (course notes and syllabus)
- 18) Hour eighteen: Practical application Technology Development (course notes and syllabus)
- 19) Hour nineteen: M&S in System Development (course notes and syllabus) P9.2-4
- 20) Hour twenty: M&S in System Development (course notes and syllabus) P9.2-4
- 21) Hour twenty-one: M&S in support of the Milestone B Decision (course notes and syllabus) A2.2-4
- 22) Hour twenty-two: M&S in system training acquisition (course notes and syllabus) A1.7
- 23) Hour twenty-three: Practical application (course notes and syllabus)
- 24) Hour twenty-four: Examination and summary (course notes and syllabus) A1, A2,P1, and P9



- 1) Course name: M&S in the Acquisition Process, Part 2
- 2) Course coordinator / point of contact and contact information  
Jim Campbell, GMU, [jcampbell@alionscience.com](mailto:jcampbell@alionscience.com), 703-933-3356
- 3) Course description: At the completion of this course, students will be able to describe the M&S used in the final phases of the Acquisition Life Cycle, using the progression of different modeling and simulation applications in use in each phase as a benchmark. They will be able to identify a particular tool and apply it appropriately to the correct point in the lifecycle and relate specific tools to the decision points that separate the acquisition phases. They will be able to identify sustainment and training support M&S for a representative system. This course is presented at the application level. For courses at the understanding or general awareness level, time can be reduced and practical application periods deleted.
- 4) Modules incorporated into Course: This course incorporates ESRs A1, A2, P2, and P9.
- 5) ESRs that the course supports This course incorporates ESRs A1 (Describe the types, role and value of formal Modeling and Simulations, and their various characterizations for application to systems management, particularly with regard to design, testing, training, production, cost estimation, manning, and logistical simulations.); A2 (Understand the critical decisions in the acquisition lifecycle and how/what M&S is used to inform those decisions in order to reduce the time resources and risk associated with the acquisition process.); P2 (Assess the costs, benefits, and risks of using physical testing, modeling and simulation, and historical data to provide information for acquisition decisions.); and P9 (Know models and simulations used in a given phase of the acquisition process, their inputs and outputs, and their capabilities and limitations.).
- 6) Prerequisites: ACQ 101, ACQ 201, Course 1A (incorporating ESRs A1, A2, P1, and P9).
- 7) Course maturity: Some of the course material is presently taught in a different format in the GMU CPE course and in the MSIAC MSSOC.
- 8) Number of contact hours and pace contemplated 24 hours, 1 three-day session
- 9) Proposed Delivery face-to-face, or VTC; resident, or customer's site
- 10) Proposed references and texts:
  - e) Acquisition M&S Course Bibliography:
    - i) Committee on Modeling and Simulation for Defense Transformation, National Research Council. Defense Modeling, Simulation, and Analysis:

Meeting the Challenge. Washington, D.C.: The National Academies Press, 2006.

- ii) Committee on Modeling and Simulation Enhancements for 21<sup>st</sup> Century Manufacturing and Defense Acquisition, National Research Council. Modeling and Simulation in Manufacturing and Defense Acquisition: Pathways to Success. Washington, D.C.: The National Academies Press, 2002.
- iii) Computer Science and Telecommunications Board. Modeling and Simulation: Linking Entertainment and Defense. Washington, D.C.: The National Academies Press, 1997.
- iv) Johnson, Michael V.R., McKeon, Mark F., and Szanto, Terrence R. Simulation Based Acquisition: A New Approach. Fort Belvoir, VA: Defense Systems Management College Press, 1998.
- v) Sabbagh, Karl. Twenty-First-Century Jet: The Making and Marketing of the Boeing 777. New York: Scribner. 1996.
- vi) Schrage, Michael. Serious Play: How the World's Best Companies Simulate to Innovate. Boston: Harvard Business School Press. 2000.
- f) Publications and Regulations
  - i) DoD Directive 5000.1, Defense Acquisition System, 12 May 2003
  - ii) DoD Instruction 5000.2, Operation of the Defense Acquisition System, 12 May 2003
  - iii) DoD Directive 5000.59, DoD Modeling and Simulation (M&S) Management, 8 August 2007
  - iv) DoD Instruction 5000.61, DoD Modeling and Simulation (M&S) Verification, Validation, and Accreditation (VV&A), 13 May 2003
  - v) Defense Acquisition Guidebook, Version 1.0, 17 October 2004
- g) Joint Chiefs
  - i) CJCSI 3170.01F, Joint Capabilities Integration and Development System, 1 May 2007
  - ii) CJCSM 3170.01C, Operation of the Joint Capabilities Integration and Development system, 1 May 2007

h) Services

- i) AR 70-1, Army Acquisition Policy, 31 December 2003
- ii) AR 5-11, Management of Army Models & Simulations, 1 February 2005
- iii) DA PAM 5-11, Verification, Validation and Accreditation of Army Models and Simulations, 30 September 1999
- iv) DA PAM 5-12, Simulation Support Planning and Plans, 2 March 2005
- v) DA Pam 70-3, Army Acquisition Procedures, 15 July 1999
- vi) SECNAVINST 5000.2C, [Operation of the Defense Acquisition System], 19 November 2004
- vii) SECNAVINST 5200.38A, Department Of The Navy Modeling And Simulation Program, 28 February 2002
- viii) OPNAVINST 5200.34, Navy Modeling and Simulation (M&S) Management, 28 May 2002
- ix) DON M&S VV&A Implementation Handbook, Volume I VV&A Framework, 30 March 2004
- x) AFRPD 63-1 Capabilities-Based Acquisition System, 10 July 2003
- xi) AFI 63-101, Operations Of Capabilities Based Acquisition System, 29 July 2005
- xii) AFRPD 16-10 Modeling And Simulation (M&S) Management, 30 January 1995
- xiii) AFI 16-1002, Modeling and Simulation (M&S) Support to Acquisition, 1 June 2000
- xiv) Department of Defense Acquisition Modeling and Simulation Master Plan, 17 April, 2006

11) Course learning objectives:

- a) A1.1: List the three types of models
- b) A1.2: Describe the purpose and characteristics of each type of model
- c) A1.3: List the three types of simulations
- d) A1.4: Describe the purpose and characteristics of each type of simulation
- e) A1.5: Describe how M&S is used in systems design
- f) A1.9: Describe how M&S is used in systems cost estimation

- g) A1.10: Describe how M&S is used in systems manpower integration
- h) A2.1: Identify the six critical decisions in the acquisition lifecycle.
- i) A2.2: Describe primary and secondary types of M&S functions that support each critical decision.
- j) A2.3: Identify the intended use of each type of M&S supporting the six critical decisions.
- k) A2.4: Identify representative examples of each type of M&S supporting the six critical decisions.
- l) P2.1: Describe the cost of physical testing vis a vis modeling and simulation, and historical data analysis
- m) P2.2: Describe the benefits of physical testing vis a vis modeling and simulation, and historical data analysis
- n) P2.3: Describe the risks of physical testing vis a vis modeling and simulation, and historical data analysis
- o) P2.4: Describe how physical test, M&S and historical data can be combined to provide effective decision support
- p) P9.1: Identify the five phases of the acquisition life cycle.
- q) P9.2: Identify the principal M&S applications used in each of the five phases of the acquisition life cycle.
- r) P9.3: Describe representative examples of M&S used for each type of application in each phase of the acquisition life cycle.
- s) P9.4: List the inputs, outputs, capabilities and limitations of each example M&S.

12) Course assessment plan: Examination, quiz, and practical exercise.

13) Topic list by hour of instruction and reference. For example:

- 1) Hour one: M&S in System Development and Demonstration (course notes and syllabus) P9.2-4
- 2) Hour two: M&S in support of the Milestone C Decision (course notes and syllabus) A2.2-4
- 3) Hour three: : Practical application (course notes and syllabus) P9, A2
- 4) Hour four: Cost considerations for test vs M&S (course notes and syllabus) P2.1
- 5) Hour five: : Benefits for test vs M&S (course notes and syllabus) P2.2
- 6) Hour six: Risk considerations for test vs M&S (course notes and syllabus) P2.3
- 7) Hour seven: Efficient Continuum of test and M&S (course notes and syllabus) P2.4,
- 8) Hour eight: Practical application (course notes and syllabus) P2 all
- 9) Hour nine: : Practical application (course notes and syllabus) P2 all
- 10) Hour ten: Quiz and review
- 11) Hour eleven: M&S in Production and Deployment (course notes and syllabus) P9.2-4
- 12) Hour twelve: M&S in support of the Full Rate Production Decision (course notes and syllabus) A2.2-4
- 13) Hour thirteen: M&S in system testing (course notes and syllabus) A1.6

- 14) Hour fourteen: M&S in system testing (course notes and syllabus) A1.6
- 15) Hour fifteen: M&S in system production (course notes and syllabus) A1.8
- 16) Hour sixteen: Practical application Production and Deployment (course notes and syllabus)
- 17) Hour seventeen: Practical application Production and Deployment (course notes and syllabus)
- 18) Hour eighteen M&S in System Sustainment (course notes and syllabus) P9.2-4
- 19) Hour nineteen: M&S in system training (course notes and syllabus) A1.7
- 20) Hour twenty: M&S in system support (course notes and syllabus)  
A1.11M&S in System Development (course notes and syllabus) P9.2-4
- 21) Hour twenty-one: Practical application (course notes and syllabus) notes and syllabus) A2.2-4
- 22) Hour twenty-two: : Practical application (course notes and syllabus)
- 23) Hour twenty-three: Examination and summary (course notes and syllabus) A1, A2,P2, and P9
- 24) Hour twenty-four: Examination and summary (course notes and syllabus) A1, A2,P2, and P9

- 1) Course name: M&S Resources and Support for the Acquisition Process
- 2) Course coordinator / point of contact and contact information  
Jim Campbell, GMU, [jcampbell@alionscience.com](mailto:jcampbell@alionscience.com), 703-933-3356
- 3) Course description (from school catalog, e.g.) At the completion of this course, students will be able to identify M&S support resources, access them and apply the information to make better M&S decisions. They will be able to apply principles of Verification, Validation and Accreditation to the process of insuring credibility of their M&S efforts and understand the roles and responsibilities of the key players in the VV&A process. This course is presented at the application level. For courses at the understanding or general awareness level, time can be reduced and practical application periods deleted.
- 4) Modules incorporated into Course This course incorporates the modules that include ESRs A5, A6, and P10
- 5) ESRs that the course supports and the corresponding level of mastery. This course incorporates ESRs A5, A6, and P10
- 6) Prerequisites: The prerequisite for this course is the M&S in the Acquisition Process course which encompasses ESRs A1, A2, P1, P2, and P9.
- 7) Course maturity: has it been taught, and if so, a brief history
- 8) Number of contact hours and pace contemplated 16 hours in 1 two-day session.
- 9) Proposed Delivery: face-to-face, or VTC; resident, or customer's site; on-line
- 10) Proposed references and texts
  - a) DoD Directive 5000.59, DoD Modeling and Simulation (M&S) Management, 8 August 2007
  - b) DoD 5000.59-P, Department of Defense Modeling and Simulation (M&S) Master Plan, October 1995
  - c) Department of Defense Acquisition Modeling and Simulation Master Plan, 17 April, 2006
  - d) Deputy Under Secretary of Defense (Science and Technology), "Charter For The Modeling and Simulation Information Analysis Center," July 15, 1999

- e) DoD Instruction 3200.14, “Principles and Operational Parameters of the DoD Scientific and Technical Information Program,” Enclosure 5 “DoD Information Analysis Centers (IACs), May 13 1997
  - f) AR 5-11, Management of Army Models & Simulations, 1 February 2005
  - g) OPNAVINST 5200.34, Navy Modeling and Simulation (M&S) Management, 28 May 2002
  - h) AFPD 16-10 Modeling And Simulation (M&S) Management, 30 January 1995DoD Instruction 5000.61, DoD Modeling and Simulation (M&S) Verification, Validation, and Accreditation (VV&A), 13 May 2003
  - i) DA PAM 5-11, Verification, Validation, & Accreditation of Army Models & Simulations, 30 September 1999
  - j) SECNAVINST 5200.40, Verification, Validation, and Accreditation (VV&A) of Models and Simulations, 19 April 1999
  - k) Air Force Instruction 16-1001, Verification, Validation and Accreditation (VV&A) 1 June 1996
  - l) Modeling and Simulation Coordination Office (MSCO) Verification, Validation, and Accreditation (VV&A) Recommended Practices Guide – RPG Build 3.0, September 2006
  - m) Department of the Navy Modeling and Simulation Verification, Validation and Accreditation Implementation Handbook, Volume I, VV&A Framework, 30 March 2004
- 11) Course learning objectives (and, again, where appropriate their mapping to the project ESRs identified in (4)).
- A5.1: Identify the DoD and service M&S structure and organizations
  - A5.2: Describe the M&S Communities
  - A5.3: Describe the role of the M&S Information Analysis Center (MSIAC)
  - A5.4: Describe the role of the MSIAC helpdesk and how to contact it for information
  - A5.5: List the M&S Coordination Agents
  - A5.6: List other M&S resources
  - A6.1: Describe the purpose of the MSRR
  - A6.2: Demonstrate proficiency in logging on to the various MSRRs
  - A6.3: Locate information in the MSRR for a specific model, simulation, data source, algorithm, or resource
  - A6.4: Describe the DoD philosophy of M&S reuse
  - P10.1: Define the terms “verification,” “validation,” and “accreditation”

- P10.2: Describe the purpose and expectations of VV&A
- P10.3: Identify the VV&A key players
- P10.4: Describe the VV&A key players roles and responsibilities
- P10.5: Identify the documentation required in the VV&A process
- P10.6: Identify the four categories of VV&A techniques
- P10.7: Describe representative VV&A techniques from each category
- P10.8: List pertinent VV&A references for DOD and representative services

12) Course assessment plan (projects, exams, papers, etc.) Examination and practical exercise.

13) Topic list by hour of instruction and reference. For example:

- 1) Hour one: Introduction and overview (course notes and syllabus) A A5.1, P10.1- P10.3, P10.8
- 2) Hour two: M&S communities and resources (course notes and syllabus), A5.2, A5.5, A5.6
- 3) Hour three: MSIAC (course notes and syllabus) A5.3, A5.4
- 4) Hour four: Introduction to the MSRR (MSMP) A6.1, A6.4
- 5) Hour five: Practical exercise (course notes and syllabus) A6.2, A6.3
- 6) Hour six: Practical exercise (course notes and syllabus) A6.2, A6.3
- 7) Hour seven: VV&A Roles and Responsibilities (course notes and syllabus) P10.4
- 8) Hour eight: Practical Exercise on VV&A Roles and Responsibilities (course notes and syllabus) P10.4
- 9) Hour nine: VV&A Documentation Requirements (course notes and syllabus) P10.5
- 10) Hour ten: Practical Exercise (course notes and syllabus) P10.5
- 11) Hour eleven: VV&A Techniques (course notes and syllabus) P10.6, P10.7
- 12) Hour twelve: VV&A Techniques (course notes and syllabus) P10.6, P10.7
- 13) Hour thirteen: Practical Exercise (course notes and syllabus) P10 all
- 14) Hour fourteen: Practical Exercise (course notes and syllabus) P10 all
- 15) Hour fifteen: Examination and summary (course notes and syllabus)
- 16) Hour sixteen: Examination and summary (course notes and syllabus)

14) Additional Requirements: This module requires student access to computers and internet connections.



## **Johns Hopkins University**

*Course Name:* Structural Mechanics, Shock and Vibration

*Course coordinator:*

Matt Lear, PhD

MS 25-262

11100 Johns Hopkins Rd.

Laurel, MD 20723

*Course description:*

Describe the fundamentals of thermodynamics and heat transfer with applications to modeling and simulation in engineering power cycles, propulsion and auxiliary system cycle analysis and design.

*Modules incorporated into Course:* E1

ESRs that the course supports and corresponding level of mastery

- 1 Key fundamental theoretical principles in structural engineering

*Competency Level:* General Awareness

- 2 Role and benefits of M&S in structural engineering, particularly Finite Element Analysis

*Competency Level:* General Awareness

- 3 Key elements of the system and component subsystem to be modeled to meet the requirements of the specific use

*Competency Level:* Understanding

- 4 Effectiveness of simulation tools used to evaluate the performance of the system and components subsystems

*Competency Level:* Understanding

*Prerequisites assumed, and corresponding level of mastery:* Understanding of college-level chemistry and physics.

*Course maturity:* None

*Number of contact hours and pace contemplated:*

- One 8 classroom hour short course OR

Proposed delivery methods:

- Face-to-face or on-line

*Module learning objectives:*

- E1.1 Basic concepts of structural mechanics and the uses of Finite Element Analysis
- E1.2 Overview of element formulations and pitfalls
- E1.3 Modeling errors and accuracy
- E1.4 Computational techniques to solve common engineering problems and appropriateness
- E1.5 Limitations of finite elements and other methods

*Course learning objectives:*

Understanding thermal aspects of military systems and how M&S is employed as a part of system verification, validation and test.

- This includes an understanding of the basic fundamentals of finite element analysis as a tool to assess system structures.
- Mastery to be demonstrated by a satisfactory score on unit quizzes and final project.

Course assessment plan:

- Satisfactory completion of course workbook and project material

Topic list by hour of instruction and reference:

Session	Time	CL	Subject Area
1	1 Hour	GA	Basic concepts of structural mechanics and Finite Element Analysis <ul style="list-style-type: none"> <li>• Finite Element Method</li> </ul>
2	1 Hour	GA	Overview of finite element formulations <ul style="list-style-type: none"> <li>• Capabilities and pitfalls</li> </ul>
3	2 Hours	U	Finite element modeling <ul style="list-style-type: none"> <li>• Commonly used applications and tools</li> <li>• Model accuracy and errors</li> </ul>
4	3 Hours	U	Computational techniques to solve common engineering problems and appropriateness <ul style="list-style-type: none"> <li>• Structural elasticity</li> <li>• Applications in aerospace, civil and mechanical engineering</li> <li>• Other industrial applications</li> </ul>
5	1 Hour	U	Limitations of finite elements and other methods

Competency Levels:

GA = General Awareness

U = Understanding

A = Application

M = Mastery

*Course Name:* Fluid Dynamics and Weapon Systems

*Course coordinator:*

Dr. Bo Cybyk and Dr. Ashish Nedungadi  
MS 25-219  
11100 Johns Hopkins Rd.  
Laurel, MD 20723

*Course description:*

Describe the fundamentals of computational fluid dynamics (CFD) with applications to modeling and simulation and Fluid dynamics of subsonic and supersonic weapons, warheads and their effects.

*Modules incorporated into Course:* E2

ESRs that the course supports and corresponding level of mastery

1. Philosophy of CFD and its role in the triad of experimental, theoretical, and numerical approaches
2. Basic governing equations for fluid dynamics, including inviscid and viscous forms suitable for CFD
3. Classes and behavior of partial differential equations; finite difference and finite volume formulations; and stability and convergence
4. Grid generation and the primary types (structured, unstructured, overset, etc.)
5. Basic CFD techniques for incompressible and compressible flows
6. Solutions of the Euler, Boundary Layer, Parabolized Navier-Stokes, and full Navier-Stokes equations in the context of subsonic and supersonic weapon applications
7. Modeling of turbulent flows, unsteady flows, and high-temperature flows in the context of subsonic and supersonic weapon applications
8. Flow visualization and data analysis techniques
9. Validation and verification methodologies using experimental, theoretical, and numerical data
10. Future of CFD in research and engineering

*Prerequisites assumed, and corresponding level of mastery:*

Understanding of college-level physics and mathematics. A basic understanding of partial differential equations would be desired.

*Course maturity:* None

*Number of contact hours and pace contemplated:*

- 10 three-four classroom hour sessions OR
- One 32 classroom hour short course OR
- This could also be broken up into two short courses
  - o Basic course consisting of modules E2.1 through E2.5. (16 classroom hours)
  - o Advanced numerical methods course would follow-on to the basic course. This would include E2.6 through E2.10 (16 classroom hours).

*Proposed delivery methods:*

- Face-to-face or on-line

*Course objectives:*

Understanding the various aspects of computational fluid dynamics and the proper use of CFD for military systems and how M&S is employed as a part of system verification, validation and test.

- This includes an understanding of the basic fundamentals of governing equations of fluid motion.
- Students will review how fluid dynamics affect military systems in tactical operations.
- Students will learn the basic steps involved in going from a CAD geometry model to final analysis of the CFD solution for applications that are relevant for military systems.
- Students will learn how to construct a good CFD models (including grids, initial conditions, and boundary conditions) for numerical analysis and how to minimize potential sources of error.
- Mastery to be demonstrated by a satisfactory score on unit quizzes and final project.

*Course assessment plan:*

- Satisfactory completion of course workbook and project material

Topic list by hour of instruction and reference:

ESR #	ESR Description	
E2	Fluid Dynamics and Weapon Systems - Understand the basics of computational fluid dynamics for CFD application and use for M&S. Fluid dynamics of subsonic and supersonic weapons, warheads and their effects.	

E2.1	Philosophy of CFD and its role in the triad of experimental, theoretical, and numerical approaches	2 hr
E2.2	Basic governing equations for fluid dynamics, including inviscid and viscous forms suitable for CFD	4 hr
E2.3	Classes and behavior of partial differential equations; finite difference and finite volume formulations; and stability and convergence	2 hr
E2.4	Grid generation and the primary types (structured, unstructured, overset, etc.)	4 hr
E2.5	Basic CFD techniques for incompressible and compressible flows	4 hr
E2.6	Solutions of the Euler, Boundary Layer, Parabolized Navier-Stokes, and full Navier-Stokes equations in the context of subsonic and supersonic weapon applications	2 hr
E2.7	Modeling of turbulent flows, unsteady flows, and high-temperature flows in the context of subsonic and supersonic weapon applications	4 hr
E2.8	Flow visualization and data analysis techniques	4 hr
E2.9	Validation and verification methodologies using experimental, theoretical, and numerical data	4 hr
E2.10	Future of CFD in research and engineering	2 hr

Competency Levels:

GA = General Awareness

U = Understanding

A = Application

M = Mastery

*Course Name:* Guidance, Navigation, and Control

*Course coordinator:*

Wayne Elliott

MS 24-E288

11100 Johns Hopkins Rd.

Laurel, MD 20723

*Course description:*

Describe the basic principles of guidance, navigation and control used in military systems that apply modeling and simulation as part of system verification, validation, test and evaluation.

*Modules incorporated into Course:* E3

*ESRs that the course supports and corresponding level of mastery*

- 1 Key fundamental theoretical principles in systems engineering  
*Competency Level: General Awareness*
- 2 Role and benefits of M&S in systems engineering  
*Competency Level: General Awareness*
- 3 Key system characteristics of the system and component subsystems of interest  
*Competency Level: General Awareness*
- 4 Key elements of the system and component subsystem to be modeled to meet the requirements of the specific use  
*Competency Level: General Awareness*
- 5 Effectiveness of simulation tools used to evaluate the performance of the system and components subsystems  
*Competency Level: Application*
- 6 Role of component-based and distributed simulation as it applies to the system and component subsystems  
*Competency Level: Application*
- 7 M&S issues related to interaction of subsystems within a larger system  
*Competency Level: Application*
- 8 VV&A implication of using a simulation of a system that is sufficiently different from its intended use  
  
*Competency Level: Application*

- 9 Level of model detail for system and component subsystems to support program milestone decision requirements

*Competency Level: Mastery*

- 10 Level of model detail for system and component subsystems to support T&E requirements

*Competency Level: Mastery*

*Prerequisites assumed, and corresponding level of mastery: None*

*Course maturity: None*

*Number of contact hours and pace contemplated:*

One 38 hour short course

This course could also be broken into two short courses.

- Basic course E3.1, E3.5, E3.8, E3.9 (18 classroom hours)
- Advanced course would include all modules.

*Proposed delivery methods:*

- Face-to-face or on-line

*Module learning objectives:*

- E3.1 Provide a basic introduction of guidance, navigation and control as they apply to military applications.
- E3.2 Provide an introduction of the types and usage of modeling and simulation for military systems that use guidance, control and navigation (Prerequisite: E3.1 or equivalent knowledge)
- E3.3 Identify the use of M&S tools to simulate guidance, navigation and control applications. (Prerequisite: E3.1 or appropriate knowledge)
- E3.4 Introduce the application of hardware in the loop simulation for guidance, navigation and control systems.
- E3.5 Introduce the uses of M&S to evaluate guidance, navigation and control systems.
- E3.6 Introduction to using M&S to predict performance.
- E3.7 Introduction to M&S, VV&A as it applied to guidance, navigation and control
- E3.8 Present the uses of M&S in guidance, navigation and control systems to support program decisions.

E3.9 Present the uses of M&S for guidance, navigation and control to support T&E requirements.

*Course learning objectives:*

Understanding of guidance, navigation and control and how M&S is employed as a part of acquisition, system verification, validation, accreditation and test.

- This includes a basic understanding of the fundamentals of guidance, navigation and control.
- Students will review types of models and simulations and their appropriate usage.
- Students will also gain insight into hardware in the loop simulation and limitations of various simulation techniques.
- Mastery to be demonstrated by a satisfactory score on unit quizzes and final project.

*Course assessment plan:*

- Satisfactory completion of course workbook and project material

Topic list by hour of instruction and reference:

Session	Time	CL	Subject Area
1	10 Hours	GA	Fundamentals of guidance, navigation and control Topics include: <ul style="list-style-type: none"> <li>• Tactical Guidance and Navigation               <ul style="list-style-type: none"> <li>○ Proportional Navigation</li> <li>○ Equations for Modeling</li> <li>○ Sample Applications</li> <li>○ Zero Effort Miss</li> <li>○ Alternate Tactical Guidance Schemes</li> <li>○ Implementation Issues and M&amp;S</li> </ul> </li> <li>• Strategic Guidance and Navigation               <ul style="list-style-type: none"> <li>○ Lambert Guidance</li> <li>○ Equations of Motion</li> <li>○ Gravitational Model</li> <li>○ Coordinate Systems</li> </ul> </li> </ul>
2	4 Hours	GA	Types and usage of M&S for guidance, navigation and control. Topics include: <ul style="list-style-type: none"> <li>• Introduction of inertial instruments               <ul style="list-style-type: none"> <li>○ Accelerometers, rate gyros, stellar monitors, strapdown systems, IMU, GPS</li> <li>○ Introduction to guidance, navigation and control error sources and models</li> </ul> </li> <li>• Model fidelity</li> <li>• Simulation structures</li> </ul>
3	4 Hours	U	Identify the use of M&S tools to simulate guidance, navigation and control. This includes: <ul style="list-style-type: none"> <li>• Whole value verses error modeling.</li> </ul>



			<ul style="list-style-type: none"> <li>• Multiple degree of freedom simulation 3D-6D</li> <li>• Equations of motion</li> <li>• Environmental models</li> </ul>
4	4 Hours	U	Introduce the application of hardware in the loop simulation for guidance, navigation and control systems. Review the associated hardware elements used in HWIL.
5	4 Hours	U	Introduce the uses of M&S to evaluate guidance, navigation and control systems. This includes: <ul style="list-style-type: none"> <li>• Single instance characteristics</li> <li>• Monte Carlo techniques</li> <li>• Modeling errors in Kalman Filters</li> <li>• Limitations of evaluation using M&amp;S</li> </ul>
6	4 Hours	A	Introduction to using M&S in conjunction with error models to predict performance in untested regimes. Topics include: <ul style="list-style-type: none"> <li>• Necessary detail of underlying models</li> <li>• Model propagation techniques</li> <li>• Sensitivity matrices, error partials</li> <li>• Limitations of predictive capability</li> </ul>
7	4 Hours	A	Introduction of M&S VV&A as it applied to guidance, navigation and control. <ul style="list-style-type: none"> <li>• Necessity of accredited simulations</li> <li>• Differences between validation and accreditation</li> <li>• Organizations responsible for components of VV&amp;A</li> </ul>
8	2 Hours	M	Present the uses of M&S in systems engineering of military systems and guidance, navigation and control systems in order to support program decisions. This includes cost, schedule and effectiveness of M&S in predicting performance.
9	2 Hours	M	Present the uses of M&S for guidance, navigation and control to support T&E requirements including establishing test cases, test sizing, test instrumentation, facility, equipment and personnel planning.

## Competency Levels:

GA = General Awareness

U = Understanding

A = Application

M = Mastery

1 Proposed references and texts:

TBS

*Course Name:* Thermodynamics and Heat Transfer

Course coordinator:

Don King, PE

MS 25-217

11100 Johns Hopkins Rd.

Laurel, MD 20723

*Course description:*

Describe the fundamentals of thermodynamics and heat transfer with applications to modeling and simulation in engineering power cycles, propulsion and auxiliary system cycle analysis and design.

*Modules incorporated into Course:* E4

ESRs that the course supports and corresponding level of mastery

- 1 Governing equations of mass, momentum, energy conservation (1st Law and 2nd Law) and heat transfer (conduction, convection, and radiation).

*Competency Level:*

- 2 Physical properties and constitutive relationships

*Competency Level:*

- 3 Thermodynamic cycles

*Competency Level:*

- 4 Combustion and chemical reactions

*Competency Level:*

- 5 Power cycle applications: steam power cycle, refrigeration, heat pumps, turbines, rockets and jets, and internal combustion engines

*Competency Level:*

- 6 Heat transfer applications: Aerodynamic heating, IR signature, satellite heating and cooling, engine cooling, electronics cooling, HVAC, solar heating, phase change

*Competency Level:*

- 7 Numerical solution techniques such as finite difference, finite volume, and finite element

*Competency Level:*

- 8 Application and limitations of finite element method to heat transfer problems

*Competency Level:*

- 9 Chemical reaction and combustion numerical methods

*Competency Level:*

## 10 Other simulation methods

*Competency Level:**Prerequisites assumed, and corresponding level of mastery:*

Understanding of college-level chemistry and physics.

*Course maturity:* None

*Number of contact hours and pace contemplated:*

- 14 three classroom hour sessions OR
- One 40 classroom hour short course OR
- This could also be broken up into two short courses
  - o Basic course consisting of modules E4.1 through E4.6. (25 classroom hours)
  - o Advanced numerical methods course would follow-on to the basic course. This would include E4.7 through E4.10 (15 classroom hours).

*Proposed delivery methods:*

- Face-to-face or on-line

*Module learning objectives:*

- E4.1 Provide a basic introduction of thermodynamics and heat transfer fundamentals and their application to the M&S of military systems.
- E4.2 Provide a fundamental understanding of material properties of interest and their use in solving thermodynamic and heat transfer problems. (Prerequisite: E4.1 or appropriate knowledge).
- E4.3 Introduce useful thermodynamic cycles and analysis approach to each and interpretation of results. (Prerequisite: E4.2 or appropriate knowledge).
- E4.4 Identify chemical reactions (including combustion-based, non-combustion, and explosive reactions) of military interest. Provide understanding of analysis approach and interpretation of results. (Prerequisite: E4.3 or appropriate knowledge).
- E4.5 Building on previous modules (E.4.1 to E4.4), solve example M&S problems focused on military applications of power cycles. (Prerequisite: E4.4 or appropriate knowledge)
- E4.6 Building on previous modules (E.4.1 to E4.4), solve example M&S problems involving heat transfer in military systems. (Prerequisite: E4.4 or appropriate knowledge)

- E4.7 Introduce a wide-range of numerical techniques and tools for solving thermodynamic and heat-transfer problems via M&S. (Prerequisite: E 4.5 and E4.6 or appropriate knowledge).
- E4.8 Apply M&S numerical methods to solve heat transfer problems using examples from military systems. (Prerequisite: E4.7 or appropriate knowledge).
- E4.9 Apply M&S numerical methods to solving combustion and chemical reaction problems using examples from military systems. (Prerequisite: E4.7 or appropriate knowledge).
- E4.10 Discuss other relevant M&S methods and techniques. (Prerequisite: E4.7 or appropriate knowledge).

*Course learning objectives:*

Understanding thermal aspects of military systems and how M&S is employed as a part of system verification, validation and test.

- This includes an understanding of the basic fundamentals of thermodynamics and heat transfer.
- Students will review how thermal issues affect use of military systems in tactical operations.
- Students will learn how to construct a good model for M&S numerical analysis and how to minimize potential sources of error.
- Mastery to be demonstrated by a satisfactory score on unit quizzes and final project.

*Course assessment plan:*

- Satisfactory completion of course workbook and project material

Topic list by hour of instruction and reference:

Session	Time	CL	Subject Area
1	3 Hours		Overview and fundamentals of thermodynamics and heat transfer in M&S. Topics include: <ul style="list-style-type: none"> <li>• Military applications</li> <li>• Control volumes</li> <li>• Conservation of mass and energy</li> <li>• Entropy</li> <li>• Heat transfer modes</li> </ul>
2	2 Hours		Material properties necessary for heat transfer and thermodynamic calculations. Topics include: <ul style="list-style-type: none"> <li>• Intrinsic vs. extrinsic properties</li> <li>• Thermodynamic properties</li> <li>• Heat transfer properties</li> </ul>
3	3 Hours		Thermodynamic cycles. This includes: <ul style="list-style-type: none"> <li>• Heat engine cycles</li> <li>• Refrigeration cycles</li> <li>• Combustion and compression</li> </ul>

			<ul style="list-style-type: none"> <li>Heat exchangers</li> </ul>
4	3 Hours		Combustion and chemical reactions. Topics include: <ul style="list-style-type: none"> <li>Combustion</li> <li>Explosive reactions</li> <li>Non-combustion chemical reactions</li> </ul>
5	6 Hours		Discuss M&S of various cycles encountered in military systems. Topics to include: <ul style="list-style-type: none"> <li>Power generation cycles</li> <li>Refrigeration and heat pumps</li> <li>Engine cycles (rocket, jet, and internal combustion)</li> </ul>
6	8 Hours		Discuss M&S of various military heat transfer problems. Example problems to include: <ul style="list-style-type: none"> <li>Electronics cooling</li> <li>Aerodynamic heating</li> <li>IR signature of vehicles</li> <li>Satellite heating and cooling</li> <li>Engine cooling</li> <li>HVAC</li> <li>Solar heating</li> <li>Phase change</li> </ul>
7	3 Hours		Introduce M&S numerical methods and modeling tools. Lay foundation for following sessions.
8	9 Hours		Discuss application and limitations of using finite element method to solve heat transfer problems. Discuss appropriate model construction level of detail and approach. Discuss sensitivity and error analysis methods. Example problems to include: <ul style="list-style-type: none"> <li>Electronics cooling</li> <li>Aerodynamic heating</li> <li>IR signature of vehicles</li> <li>Satellite heating and cooling</li> </ul>
9	1.5 Hours		Discuss M&S numerical methods to solve chemical reaction and combustion problems. Example problems to include: <ul style="list-style-type: none"> <li>Propellant chemistry</li> <li>Rocket exhaust IR analysis</li> </ul>
10	1.5 Hours		Introduce other M&S methods (primarily empirical).

Competency Levels:

GA = General Awareness

U = Understanding

A = Application

M = Mastery

*Course Name:* Materials and Fabrication

*Course coordinators:*

Andrew M. Lennon

Michael Rooney

MS 13-N209

David Drewry

MS 25-N217

11100 Johns Hopkins Rd.

Laurel, MD 20723

*Course description:*

Describe the basic materials technology associated with manufacturing, welding and corrosion control. Have an introduction to composite, superconducting materials, and fiber optics as applied to M&S.

*Modules incorporated into Course:* E5

*ESRs that the course supports and corresponding level of mastery*

- 1 Key fundamental theoretical principles in materials science  
*Competency Level:* General Awareness
- 2 Role and benefits of M&S in materials science  
*Competency Level:* Application
- 3 Key characteristics of engineering materials of interest  
*Competency Level:* Understanding
- 4 Key characteristics of materials to be modeled to meet the requirements of the specific use  
*Competency Level:* Understanding
- 5 Effectiveness of simulation tools used to evaluate the performance of materials for the specific use  
*Competency Level:* Application
- 6 M&S issues related to interaction of materials within a larger system  
*Competency Level:* Application
- 7 Level of model detail for material testing to support program milestone decision requirements  
*Competency Level:* Application
- 8 Level of model detail for materials testing to support T&E requirements

*Competency Level:*        *Application*

*Prerequisites assumed, and corresponding level of mastery:* None

*Course maturity:* None

*Number of contact hours and pace contemplated:*

- 14 three classroom hour sessions OR
- One 40 classroom hour short course

*Proposed delivery methods:*

- Face-to-face or on-line

*Module learning objectives:*

- E5.1 Provide a basic introduction and review of materials science, including discussion of stress/strain definitions and relationship and the different classes/types of materials and their uses. More detailed discussion of governing equations are covered in ESR E1.1.
- E5.2 Discuss the fundamental behavior of metals, their methods of manufacture and the effect of fabrication parameters and other factors (e.g., strain rate, temperature) on their final properties. Discussions to include heat treatment, strain hardening and corrosion.
- E5.3 Discuss the fundamental behavior of ceramics and glasses, their methods of manufacture and the effect of fabrication parameters and other factors on final properties.
- E5.4 Discuss the fundamental behavior of polymeric materials, their methods of manufacture and the effect of fabrication parameters and environmental factors on final properties.
- E5.5 Discuss the fundamental behavior of composite materials, their methods of manufacture and the effect of fabrication and other parameters on final properties.
- E5.6 Discuss the manufacture and behavior of novel materials such as superconductors, fiber optics, etc.
- E5.7 Provide a basic understanding of material joining techniques (i.e., welding, adhesive bonding, bolted joints) and methods of estimating/ measuring their impact on interfacial and overall properties.

- E5.8 Provide a general overview of testing methods for determining the various material properties used in M&S, including both quasi-static and dynamic/high-rate methods. Discussions will also be presented on detection and quantification of manufacturing and/or material defects and their impact on M&S, which will include an overview of NDE methods.
- E5.9 Discuss general classes of material coatings and their applications, such as corrosion and wear prevention.

*Course learning objectives:*

Develop an understanding of materials science fundamentals relevant to materials selection for specific applications.

- Become familiar with different classes of engineering materials and their trade-offs associated with strength, toughness, corrosion-resistance, fabricability and cost.
- Learn M&S techniques for coupon-level evaluation materials properties.
- Gain an awareness of fabrication and joining techniques for different materials classes, as well as coatings for enhancing properties of the materials system.
- Demonstrate mastery of course objectives through unit quizzes and final examination.

*Course assessment plan:*

- Satisfactory completion of course workbook and project material

Topic list by hour of instruction and range of competency levels:

Session	Time	CL	Subject Area
1	4 Hours	GA	<p>Introduction to materials science fundamentals</p> <ul style="list-style-type: none"> <li>• Definition of material stress and strain</li> <li>• Stress/strain relationships               <ul style="list-style-type: none"> <li>○ Modulus</li> <li>○ Yield point</li> <li>○ Toughness (strain energy)</li> <li>○ Ductility (elongation to break)</li> </ul> </li> <li>• Multiaxial stress states               <ul style="list-style-type: none"> <li>○ Hydrostatic pressure</li> <li>○ Biaxial tension</li> <li>○ Tension-torsion</li> <li>○ Deviatoric stress decomposition</li> </ul> </li> <li>• Material Anisotropy</li> <li>• Classes of engineering materials               <ul style="list-style-type: none"> <li>○ Metals</li> <li>○ Ceramics and glasses</li> <li>○ Polymeric materials</li> <li>○ Compositites                   <ul style="list-style-type: none"> <li>▪ Fiber reinforced composites</li> <li>▪ Particle reinforced composites</li> </ul> </li> <li>○ Specialty materials</li> </ul> </li> </ul>



			<ul style="list-style-type: none"> <li>▪ Fiber optics</li> <li>▪ Superconducting materials</li> </ul>
2	6 Hours	GA thru U	Behavior of engineering metals <ul style="list-style-type: none"> <li>• Work hardening</li> <li>• Heat treatment</li> <li>• Characteristics of Common Engineering Metals               <ul style="list-style-type: none"> <li>o Common steels</li> <li>o Alloy steels</li> <li>o Stainless steels</li> <li>o Non-Ferrous alloys                   <ul style="list-style-type: none"> <li>– Aluminum alloys</li> <li>– Copper alloys</li> <li>– Nickel alloys</li> <li>– Magnesium alloys</li> <li>– Specialty alloys</li> </ul> </li> </ul> </li> <li>• Corrosion               <ul style="list-style-type: none"> <li>o Galvanic corrosion</li> <li>o Pitting corrosion</li> <li>o Stress corrosion cracking</li> <li>o High temperature oxidation</li> </ul> </li> <li>• Creep</li> <li>• Fabrication methods               <ul style="list-style-type: none"> <li>o Casting</li> <li>o Extrusion, rolling and forging</li> <li>o Machining (milling, turning, grinding, EDM)</li> <li>o Powder metallurgy</li> </ul> </li> </ul>
3	2 Hours	GA thru U	Behavior of engineering ceramics and glasses <ul style="list-style-type: none"> <li>• Brittle fracture</li> <li>• Griffith fracture criterion               <ul style="list-style-type: none"> <li>o Flaw-dominated strength</li> <li>o Cracking modes</li> <li>o Fracture toughness</li> </ul> </li> <li>• Fabrication techniques               <ul style="list-style-type: none"> <li>o Casting</li> <li>o Sintering</li> <li>o Grinding</li> </ul> </li> </ul>
4	3 Hours	GA thru U	Behavior of engineering polymers <ul style="list-style-type: none"> <li>• Viscoelasticity and the complex modulus</li> <li>• Stress relaxation and creep</li> <li>• Glass transition</li> <li>• Thermal breakdown</li> <li>• Common polymeric materials               <ul style="list-style-type: none"> <li>o Thermosets (e.g. bakelite)</li> <li>o Thermoplastics (e.g. polycarbonate)</li> </ul> </li> <li>• Fabrication techniques</li> </ul>

			<ul style="list-style-type: none"> <li>○ Injection molding</li> <li>○ Casting</li> <li>○ Extrusion</li> </ul>
5	4 Hours	GA thru U	<p>Behavior of engineering composite materials</p> <ul style="list-style-type: none"> <li>● Resin matrix composites               <ul style="list-style-type: none"> <li>○ Epoxies</li> <li>○ Cyanate and Vinyl esters</li> <li>○ Polyurethane</li> </ul> </li> <li>● Fiber Reinforcements               <ul style="list-style-type: none"> <li>○ Fibers, tows and fabrics</li> <li>○ E- and S-glass</li> <li>○ Carbon</li> </ul> </li> <li>● Metal and Ceramic matrix composites</li> <li>● Frabrication Techniques               <ul style="list-style-type: none"> <li>○ VARTM</li> <li>○ Press molding</li> <li>○ Prepreg/Autoclave</li> <li>○ Filament Winding</li> <li>○ Pultrusion</li> </ul> </li> </ul>
6	2 Hours	GA thru U	<p>Properties of novel materials</p> <ul style="list-style-type: none"> <li>● Superconducting materials               <ul style="list-style-type: none"> <li>○ Mechanical properties</li> <li>○ Thermal properties</li> <li>○ Fabrication process</li> </ul> </li> <li>● Optical fibers               <ul style="list-style-type: none"> <li>○ Mechanical properties</li> <li>○ Fabrication processes</li> <li>○ Joining processes</li> </ul> </li> </ul>
7	4 Hours	GA thru A	<p>Material joining techniques</p> <ul style="list-style-type: none"> <li>● Welding               <ul style="list-style-type: none"> <li>○ Filler material selection</li> <li>○ Heat affected zone</li> <li>○ Corrosion considerations</li> </ul> </li> <li>● Fasteners               <ul style="list-style-type: none"> <li>○ Torque specification</li> <li>○ Shear properties (bolt-shear, thread shear, substrate shear-out)</li> <li>○ Corrosion considerations</li> </ul> </li> <li>● Adhesive bonding</li> </ul>
8	10 Hours	GA thru A	<p>Modeling and Simulation</p> <ul style="list-style-type: none"> <li>● Mechanical test methods               <ul style="list-style-type: none"> <li>○ Load frames                   <ul style="list-style-type: none"> <li>▪ Tension, compression, shear</li> <li>▪ Bend testing</li> <li>▪ Peel testing</li> </ul> </li> </ul> </li> </ul>

			<ul style="list-style-type: none"> <li>▪ Load vs. deflection of structures</li> <li>○ Hardness Testing</li> <li>○ Wear testing</li> <li>• Thermal analysis <ul style="list-style-type: none"> <li>○ DMA – Dynamic Mechanical Analysis</li> <li>○ (M)DSC – (Modulated) Differential Scanning Calorimetry</li> <li>○ TGA – Thermogravimetric analysis</li> <li>○ Flash diffusivity/thermal conductivity</li> <li>○ Accelerated life testing</li> </ul> </li> <li>• High rate testing <ul style="list-style-type: none"> <li>○ Charpy impact testing</li> <li>○ Drop towers</li> <li>○ Kolsky bar (split-Hopkinson pressure bar)</li> </ul> </li> <li>• Corrosion Testing <ul style="list-style-type: none"> <li>○ Stress-corrosion cracking methods</li> <li>○ Salt spray exposure</li> <li>○ Immersion methods</li> <li>○ High temperature exposure standards</li> </ul> </li> <li>• Non-Destructive Evaluation (NDE) <ul style="list-style-type: none"> <li>○ Dye penetration</li> <li>○ Magnetic particle</li> <li>○ Radiographic inspection</li> <li>○ Ultrasonic inspection</li> <li>○ Eddy current inspection</li> <li>○ Thermography</li> <li>○ Shearography</li> </ul> </li> </ul>
9	3 Hours	GA thru U	Coatings <ul style="list-style-type: none"> <li>• Paints</li> <li>• Powder coatings</li> <li>• Platings</li> <li>• Conversion coatings</li> <li>• Nitriding and carburization</li> <li>• Thermal/plasma spray coatings</li> <li>• Sputtered or vacuum deposited coatings</li> </ul>

Competency Levels:

GA = General Awareness

U = Understanding

A = Application

M = Mastery

*Course Name:* Networks

*Course coordinator:*

Chris Ryder

MS 25-262

11100 Johns Hopkins Rd.

Laurel, MD 20723

*Course description:*

Describe the basic principles of communications networks used in military operations and on military systems that apply modeling and simulation as part of system verification, validation and test. Included in this course is assessing the integration of military systems into the Global Information Grid. Students will also model network topologies and parameters based on operational requirements

*Modules incorporated into Course:* E11

*ESRs that the course supports and corresponding level of mastery*

- 1 Key fundamental theoretical principles in systems engineering  
*Competency Level: General Awareness*
- 2 Role and benefits of M&S in systems engineering  
*Competency Level: General Awareness*
- 3 Key system characteristics of the system and component subsystems of interest  
*Competency Level: General Awareness*
- 4 Key elements of the system and component subsystem to be modeled to meet the requirements of the specific use  
*Competency Level: General Awareness*
- 5 Effectiveness of simulation tools used to evaluate the performance of the system and components subsystems  
*Competency Level: Application*
- 6 Role of component-based and distributed simulation as it applies to the system and component subsystems  
*Competency Level: Application*
- 7 M&S issues related to interaction of subsystems within a larger system  
*Competency Level: Application*

- 8 VV&A implication of using a simulation of a system that is sufficiently different from its intended use

*Competency Level: Application*

- 9 Level of model detail for system and component subsystems to support program milestone decision requirements

*Competency Level: Mastery*

- 10 Level of model detail for system and component subsystems to support T&E requirements

*Competency Level: Mastery*

*Prerequisites assumed, and corresponding level of mastery:*

Understanding of military communications and their application.

*Course maturity: None*

*Number of contact hours and pace contemplated:*

- 14 three classroom hour sessions OR
- One 40 classroom hour short course OR
- This could also be broken up into two short courses
  - o Basic course consisting of modules E11.1 through E11.5 along with E11.9 and E11.10. (24 classroom hours)
  - o Advanced course would be a follow-on to the basic course. This which would include E11.6 through E11.8 (16 classroom hours).

*Proposed delivery methods:*

- This class is best suited for classroom environment where the students will have the ability to utilize a basic M&S application used for communications networks.
- An alternative would be for an online course in which an network related M&S application is integrated into the courseware

*Module learning objectives:*

- E11.1 Provide a basic introduction of communications networks, including data and voice communications and military applications of networks.
- E11.2 Provide an introduction of the types and usage of modeling and simulation for military systems that facilitates military data and voice communications (Prerequisite: E11.1 or appropriate knowledge)
- E11.3 Assess the impact of force structure and operational missions to communications requirements for military systems. Analyze requirements for network topologies, ports, parameters and information exchanges

- E11.4 Identify the use of M&S tools to simulate communications networks for military applications. (Prerequisite: E11.3 or appropriate knowledge)
- E11.5 Building operational scenarios and applying M&S tools and processes to determine predicted and actual network data loading and bandwidth demands. (Prerequisite: E11.4 or appropriate knowledge)
- E11.6 Design of network topology with appropriate data loading and bandwidth to accommodate operational scenarios. (Prerequisite: E11.5 or appropriate knowledge)
- E11.7 Hardware in the loop simulation of link and physical layers for communications equipment including routers, switches and radios (Prerequisite: E11.6 or appropriate knowledge)
- E11.8 Uses of M&S to assess network and transport layer communications protocols including broadcast and specific addressed messages. (Prerequisite: E11.6 or appropriate knowledge)
- E11.9 Discuss the utility of M&S for system communications and network integration to support program decisions
- E11.10 Discuss how M&S for system communications and network integration is used to support T&E requirements

*Course learning objectives:*

Understanding of integration of military systems with voice and data communications networks and how M&S is employed as a part of system verification, validation and test.

- This includes an understanding of communications network protocols including the Open Systems Institute (OSI) communications model and TCP/IP.
- Students will review how military operations correlate to communications requirements, including basic design of a communications network.
- Students will also gain insight into hardware in the loop simulation of the link and physical elements of communications networks as well as M&S applications for broadcast and addressed messages at the application and transport layers.
- Mastery to be demonstrated by a satisfactory score on unit quizzes and final project.

*Course assessment plan:*

- Satisfactory completion of course workbook and project material

Topic list by hour of instruction and reference:

Session	Time	CL	Subject Area
1	4 Hours	GA	Fundamentals of communications networks for voice and data communications. Topics include: <ul style="list-style-type: none"> <li>• Open Systems Institute Architecture</li> </ul>

			<ul style="list-style-type: none"> <li>• TCP/IP</li> <li>• Analog and digital data transmissions</li> <li>• Transmission media</li> <li>• Data encoding</li> </ul>
2	2 Hours	GA	<p>Types and usage of M&amp;S for military systems that utilize voice and data communications. Topics include:</p> <ul style="list-style-type: none"> <li>• Campaign level M&amp;S <ul style="list-style-type: none"> <li>o Simulating the battlefield and its communications</li> </ul> </li> <li>• Mission level M&amp;S <ul style="list-style-type: none"> <li>o Simulating the “mission thread” for system under evaluation</li> </ul> </li> <li>• Engineering level M&amp;S <ul style="list-style-type: none"> <li>o Simulating technical properties of the weapon system and its communications subsystems</li> </ul> </li> </ul>
3	5 Hours	U	<p>Assess the impact of force structure and operational missions to communications requirements for military systems. This includes:</p> <ul style="list-style-type: none"> <li>• Understanding operational nodes, composition and location</li> <li>• Determination of missions to be performed with associated data elements and information exchanges</li> <li>• Evaluating the communication requirements to execute the operations</li> </ul> <p>Analyze requirements for network topologies, ports, parameters and information exchanges. This includes:</p> <ul style="list-style-type: none"> <li>• Introducing the concept of network and its related attributes that can meet the communications requirements</li> </ul>
4	4 Hours	U	<p>Identify the use of M&amp;S tools to simulate communications networks for military applications. This includes hands on use of an available M&amp;S tool and how that tool is utilized to develop a network and simulate it in the required environment.</p>
5	5 Hours	U	<p>Building operational scenarios and applying M&amp;S tools and processes to determine predicted and actual network data loading and bandwidth demands. This is a “hands on” exercise to apply the lesson learned in Session 3 using the tool introduced in Session 4.</p>
6	8 Hours	A	<p>Design a communications network based on the lessons learned in Sessions 4 and 5. Factor the data channels and pipelines with the required bandwidth.</p>
7	4 Hours	A	<p>Introduce the application of hardware in the loop simulation for communications systems and subsystems over link and physical layers. Review the associated hardware elements used in HWIL.</p>
8	4 Hours	A	<p>Introduce the uses of M&amp;S to evaluate communications over the network and transport layers of network. This includes use</p>

			of addressed messages that go to a specific recipient as well as broadcast messages that are received by multiple addressees.
9	2 Hours	M	Present the uses of M&S in systems engineering of military systems and their communications subsystems in order to support program decisions. This includes cost, schedule and effectiveness of M&S in network systems engineering.
10	2 Hours	M	Present the uses of M&S for communications systems to support T&E requirements including establishing test cases, facility, equipment and personnel planning.

## Competency Levels:

GA = General Awareness

U = Understanding

A = Application

M = Mastery

## Proposed references and texts:

[1] Stallings, William; Data and Computer Communications; Prentice Hall, Upper Saddle River, NJ



*Course Name:* M&S Taxonomies, Hierarchies, and Architectures

*Course coordinator*

Robert R. Lutz  
MS 25-262  
11100 Johns Hopkins Rd.  
Laurel, MD 20723u

*Course description*

Application-based characterization of M&S applications by taxonomy (live, virtual, and constructive) and hierarchy (campaign, missions, engagement, and engineering), including selection criteria. Also includes the role of M&S in systems architecture development and implementation, along with resulting M&S architecture solutions.

*Modules incorporated into course*

P4(1)-G M&S Taxonomies and Hierarchies (General awareness)  
P4(1)-U M&S Taxonomies and Hierarchies (Understanding)  
P4(1)-A/M M&S Taxonomies and Hierarchies (Application/Mastery)

*ESRs that the course supports and the corresponding level of mastery*

ESR P4(1) General awareness, Understanding, Application, and Mastery

*Prerequisites assumed, and corresponding level of mastery*

Basic familiarity with M&S concepts, equivalent to MSIAC M&S Staff Officers Course.

*Course maturity*

Not previously taught as a course, although some of this material has been taught in other courses (e.g., Certified Modeling and Simulation Professional examination preparation course) and in M&S tutorials given by external M&S organizations (e.g., I/ITSEC).

*Number of contact hours and pace contemplated*

Semester course: 8 lecture hours per week for 3 days.

*Proposed delivery modality*

Face-to-face lecture would be preferred, but asynchronous distance learning (web or CD) is also possible.

*Proposed references and texts*

- [1] Piplani, L., Mercer J, Roop R., "Systems Acquisition Manager's Guide for the Use of Models and Simulations", Defense Systems Management College, 1994.
- [2] Law A., "Simulation Modeling and Analysis", Fourth Edition, McGraw-Hill, 2007.
- [3] Lutz R., "Modeling and Simulation in the Systems Engineering Process", *Introduction to Systems Engineering* Lecture Notes, 2006.
- [4] Lutz R., "Simulation Based Acquisition: Concepts and Trends", INCOSE Meeting Presentation, 2002.
- [5] "Operation of the Defense Acquisition System", DoDI 5000.2, 2003.

[6] "Systems Engineering – System Life Cycle Processes", IEEE 15288, 2004.

[7] "High Level Architecture", IEEE 1516, 2001.

### *Course learning objectives*

Correspond to sub-ESRs for ESR P4(1):

- a) P4(1).1 Provides an overview of basic M&S concepts, including benefits and limitations of using M&S.
- b) P4(1).2 Provides a general overview of how M&S supports systems engineering, including the different classes of M&S users (e.g., T&E, training, analysis, ...)
- c) P4(1).3 Provides an introduction to the Live, Virtual, and Constructive taxonomy of models and simulations, and discusses the criteria for selecting when each is most appropriate.
- d) P4(1).4 Provides an introduction to the concept of model fidelity and model resolution. Discusses the standard M&S model hierarchy from campaign-level to engineering-level, and the criteria for selecting when each is most appropriate.
- e) P4(1).5 Provides an introduction to the concept of "architecture", including how M&S is used to support the evaluation of system architectures.
- f) P4(1).6 Describes the concept of "architecture" from the M&S perspective, including modern mechanisms for developing and describing M&S architectures.

### *Course assessment plan*

Results of team projects performed on last day.

### Topic list by hour of instruction and reference

Listed for each hour are topic description, related sub-ESR, and reference (if any).

1. Identify and describe basic M&S concepts, including benefits and limitations of using M&S, P4(1).1, [1], [2]
2. Provide examples that illustrate the fundamental concepts underlying M&S and demonstrate M&S benefits and limitations, P4(1).1, [1], [2]
3. Describe how M&S supports systems engineering, including the different classes of M&S users (e.g., T&E, training, analysis, ...), P4(1).2, [1], [3], [4]
4. Show how M&S supports the DoD 5000 systems acquisition process, including examples across the various classes of M&S users (e.g., T&E, training, analysis, ...), P4(1).2, [1], [3], [4], [5]
5. Show how M&S supports the DoD 5000 systems acquisition process, including examples across the various classes of M&S users (continuation of previous lecture), P4(1).2, [1], [3], [4], [5]
6. Show how M&S supports the IEEE 15288 systems engineering process. Provide examples where appropriate, P4(1).2, [6]
7. Introduce the Live, Virtual, and Constructive (LVC) taxonomy of models and simulations, P4(1).3, [1]
8. Conclude LVC introduction (from previous lecture). Explain the criteria for selecting among Live, Virtual, and Constructive M&S assets for different types of applications, P4(1).3, [1]
9. Conclude selection criteria discussion (from previous lecture). Using case studies, determine an appropriate set of selection criteria for choosing among Live, Virtual,

- and Constructive M&S assets within each application area, and apply those criteria appropriately, P4(1).3
10. Using case studies, determine an appropriate set of selection criteria for choosing among Live, Virtual, and Constructive M&S assets within each application area, and apply those criteria appropriately (continuation of previous lecture), P4(1).3
  11. Conclude LVC case studies from previous lecture. Introduce the concept of model fidelity and model resolution. Outline the standard M&S model hierarchy from campaign-level to engineering-level, P4(1).4, [1]
  12. Conclude discussion of model fidelity, model resolution, and model hierarchy (continuation of previous lecture), P4(1).4, [1]
  13. Explain the criteria for selecting among M&S assets across the various levels of the M&S hierarchy for different types of applications, P4(1).4, [1]
  14. Using case studies, determine an appropriate set of selection criteria for choosing among M&S assets across the various levels of the M&S hierarchy for each application area, and apply those criteria appropriately, P4(1).4
  15. Using case studies, determine an appropriate set of selection criteria for choosing among M&S assets across the various levels of the M&S hierarchy for each application area, and apply those criteria appropriately (continuation of previous lecture), P4(1).4
  16. Introduce the concept of "architecture" and how it supports systems engineering, P4(1).5, [4]
  17. Describe how M&S is used to support the evaluation of system architectures, P4(1).5, [3], [4]
  18. Illustrate how M&S is used to support the evaluation of system architectures through a chosen set of examples, P4(1).5, [3], [4]
  19. Illustrate how M&S is used to support the evaluation of system architectures through a chosen set of examples (continuation of previous lecture), P4(1).5, [3], [4]
  20. Demonstrate the use of an M&S tool to evaluate a system architecture. Discuss the different types of M&S tools that are available to support this function, P4(1).5
  21. Demonstrate the use of an M&S tool to evaluate a system architecture. Discuss the different types of M&S tools that are available to support this function (continuation of previous lecture), P4(1).5
  22. Describe the concept of "architecture" from the M&S perspective, including modern mechanisms for developing and describing M&S architectures., P4(1).6, [3], [4]
  23. Provide examples of existing M&S architectures. For one such example, show how the architecture was developed, P4(1).6, [3], [4]
  24. Analyze a selected M&S architecture. Discuss the relevant design issues and how they were resolved, P4(1).6, [7]

## 2.5 Engineering Case Studies

A series of engineering case studies were assembled as supplemental material for the program. These eleven cases studies focus on the use of physics based modeling and simulation in the acquisition of new systems. The topics range from the modeling of new nanotechnology implementations in heat transfer systems to the simulation of weapons system accuracy.

The complete list of case study titles is presented in Table 2.5.1.

**Table 2.5.1. Engineering Case Study Titles**

No.	Title
1	Ship Maneuvering and Control for DoD Acquisition
2	Ship Shock Simulation: Survivability as an Integral Part of Ship Acquisition
3	Life Limiting Damage in Railguns: Role of Modeling & Simulation in Root Cause Analysis, Design and Acquisition
4	Finite Element Analysis to Reduce Acquisition Cost
5	Assessing Design Adequacy of a Common Machine Part
6	Improving the Fuel Efficiency of Light Trucks
7	The Use of Modeling and Simulation to Assess Weapon System Performance
8	Ocean Modeling and Simulation for DoD Acquisition
9	Thermo-mechanical Analysis of Directed Energy Weapons on Satellites - M&S with Acquisitions Perspective
10	The Importance of Heat Transfer Engineering in Making Knowledge Based Decision by the Acquisition Workforce
11	Modeling and Simulation as an Integral Part of Accessing Overall System's Performance and Control Robustness

A desired outcome of this compilation of typical engineering M&S examples is to familiarize the acquisition profession with some of the typical representations of engineering M&S that they may be exposed to in future acquisition programs. In some instances the types of engineering models and simulations presented may already be familiar to the reader, while others may not be as commonplace.

As these case studies are primarily aimed at acquisition professionals who do not possess an engineering degree or perhaps do not have a strong background in physics based M&S, an emphasis is placed on describing the underlying engineering concepts. Each walks

the reader through the basic steps in taking a physical object and correctly translating its motions, characteristics and physical attributes into the computer model and simulation environment.

It is envisioned that the use of these case studies involving examples of real systems will facilitate the drawing of links between design changes and level of specificity in the engineering M&S process and their resulting impacts on the overall acquisition process in terms of cost, schedule and performance.

The greater purpose for the use of engineering case studies as an integral part of the “Workforce Modeling & Simulation Education and Training Lifelong Learning” program was twofold. First, the case studies were to address the introduction of engineering M&S concepts and their application to the acquisition process as has been previously described. Secondly, the case studies were meant to be used as a development tool in the standardization for the design and feel of proposed delivery methods for the web-based learning tools stemming from the project.

In examining the web-based product we will use the Ship Shock Simulation: Survivability as an Integral Part of Ship Acquisition” provided by Professors Young Shin and Jarema M. Didoszak of the Naval Postgraduates School Department of Mechanical and Astronautical Engineering as our example. This case study outlines the use of finite element modeling and simulation of the USS WINSTON S. CHURCHILL (DDG-81) full ship shock trials.

Each of the engineering case studies follows the standardized format that is outlined here:

- Executive Summary
- Engineering Relevance
- DoD Acquisition Relevance
- Engineering Modeling and Simulation Approach
- Summary & Lessons Learned
- Acknowledgements
- References
- Author(s) Information
- Glossary

Figure 2.5.1 is an actual screen shot of the web-based learning module from the ship shock trial case study. Articulate®, a commercial e-learning creation package, was used to convert standard lecture material into interactive web-based content. This figure also shows the implementation of the full project moniker as is displayed at the start of each case study module. Additionally the project logo is found at the upper left corner of the course module screen. The aim here is to catch peoples’ interest and draw them into the course modules, proposed certificate programs and other learning tools through the consistent branding of all materials associated with the project.



Figure 2.5.1. Screen Shot of Introductory Page

In the subsequent series of screen shots, Figures 2.5.2-5, some of the web-based e-learning features in the menus at the left side of the courseware are highlighted. The default mode, as shown in Figure 2.5.2, lists the slide titles vertically. The student may skip ahead to a particular slide any where in the course module as necessary. The table of contents shown in Figure 2.5.2 also illustrates the use of embedded hyperlinks that also quick movement through the content if it is being used as a reference or when restarting a module.

Others common features that should be pointed out are the typical navigation tools found along the lower portion of the screen, such as play, pause, volume and window size controls. At the top of the screen are the case study title and the runtime for the module. The case studies are approximately 30 minutes in length.

Figure 2.5.3 shows the thumbnail feature which is similar to the normal slide view in Microsoft PowerPoint. Selecting a thumbnail by clicking on the image advances the module to that particular slide.

Ship Shock Simulation: Survivability as an Integral Part of Ship Acquisition (04:35 / 29:14)

**Modeling and Simulation**  
Educating the DoD Communities and Services

Outline Thumbnails Search Text

1. Introduction  
2. Executive Summary  
3. Full Ship Shock Live Fire Test & Eval  
4. Modeling UNDEX in a Virtual Enviro  
5. Table of Contents  
6. Engineering Relevance  
7. Engineering Relevance  
8. Engineering Relevance  
9. DoD Acquisition Relevance  
10. DoD Acquisition Relevance  
11. Defining the Threat Type  
12. Ship Threat Environments  
13. Proximity of Blast  
14. Ship Shock Trials- LFT&E  
15. Ship Shock Trials- Instrumentation  
16. Ship Shock Trials- Instrumentation  
17. DDG 81 Shock Trials  
18. DDG 81 Shock Trials  
19. UNDEX Phenomena  
20. UNDEX Phenomena  
21. Modeling & Simulation Approach  
22. DDG 81 Finite Element Model  
23. Fluid Mesh Construction  
24. DDG-81 Finite Element Model

**Table of Contents**

TOPIC	SLIDE
<a href="#">Executive Summary</a>	2
<a href="#">Engineering Relevance</a>	6
<a href="#">DoD Acquisition Relevance</a>	9
<a href="#">Modeling &amp; Simulation Approach</a>	21
<a href="#">Summary &amp; Lessons Learned</a>	30
<a href="#">Acknowledgements</a>	33
<a href="#">Author Information</a>	34
<a href="#">Glossary</a>	36

(Click on the links in the left-hand column to go to a specific slide)



5

SLIDE 5 OF 37 CLICK NEXT TO ADVANCE 00:50 / 00:50

TEXT

Figure 2.5.2. Screen Shot Depicting Outline Feature

Ship Shock Simulation: Survivability as an Integral Part of Ship Acquisition (05:15 / 29:14)

**Modeling and Simulation**  
Educating the DoD Communities and Services


Outline Thumbnails Search Text

5. Table of Contents  
6. Engineering Relevance  
7. Engineering Relevance

**Engineering Relevance**

**Technical Problem**

- Combatant vessels are subjected to underwater explosions
- Shock requirements exist as part of the ship survivability evaluation process in building a new ship class for the Navy
- Ship design must be tested to ensure minimal standards are met to ensure the survivability/safety of ship, systems & crew



6

SLIDE 6 OF 37 CLICK NEXT TO ADVANCE 00:39 / 00:39

TEXT

Figure 2.5.3. Screen Shot Depicting Slide Thumbnail Feature

Once again looking to the left of the screen, in Figure 2.5.4 we find a useful search function that lists out the pages in which the desired word is found on. Here the sought after word was “Navy” and was found on pages 1, 6, 13, 17, 27, 30, 35, and 36 of the ship shock simulation case study module.

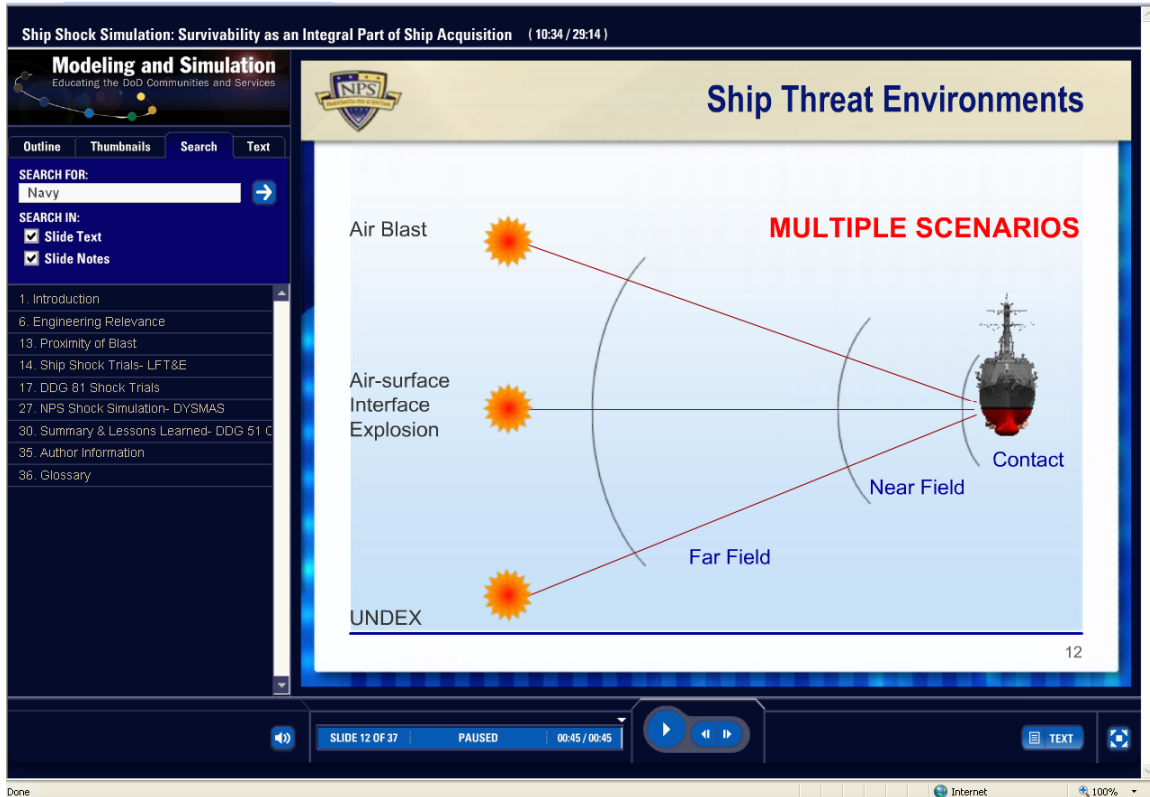


Figure 2.5.4. Screen Shot Depicting the Search Feature

Figure 2.5.5 demonstrates use of the narration text feature which lists the runtime for that particular page along with the full text of the presentation. This can be a useful feature if training is being accomplished in an office setting while the sound is turned off.

Other e-learning features can only be experienced through the actual running of the courseware module. Motion graphics, highlighted text, video clips and other animations are a few of the interactive items found throughout the content to help engage the student. For example in Figure 2.5.5, page 27 of the case study, embedded movie files are used to visualize the shockwave propagation of the underwater explosion.

Finally in Figure 2.5.6 we see an example of the glossary that is found at the end of each of the case study course modules. Key engineering terms from each case study that may not be familiar to the acquisition professional were added in this section as a reference.



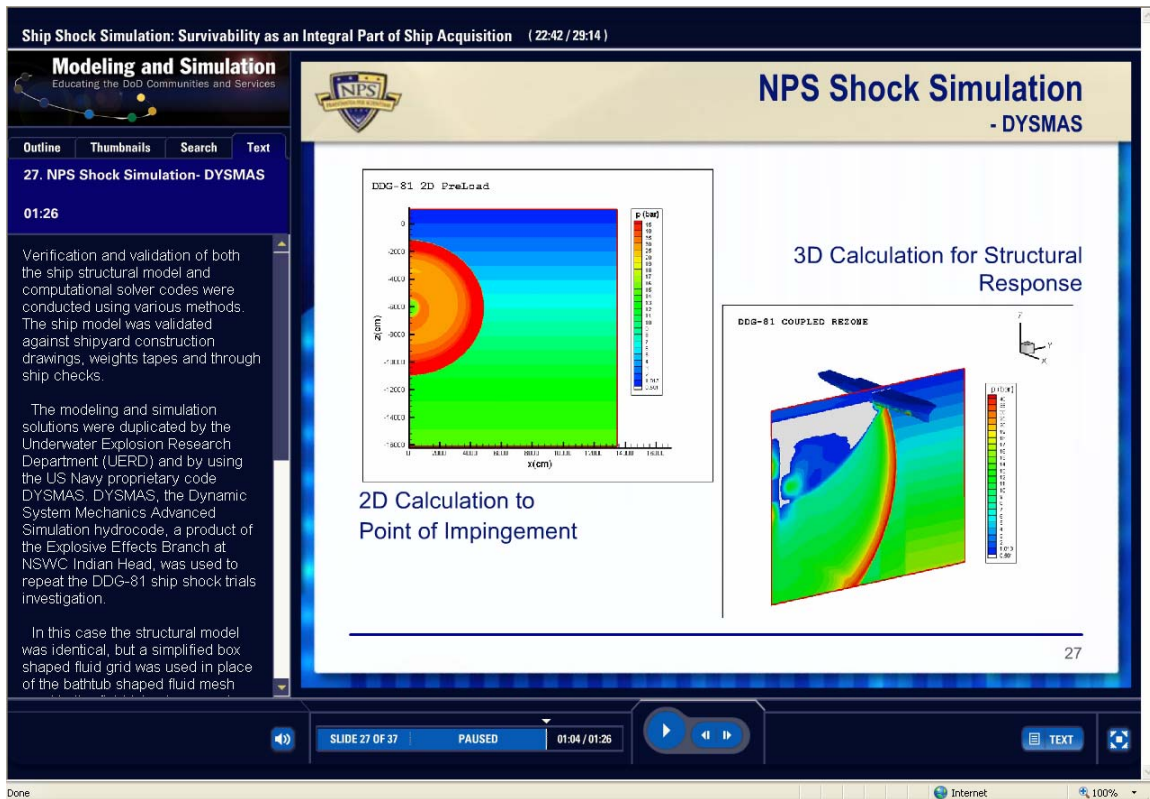


Figure 2.5.5. Screen Shot Depicting Narration Text Feature

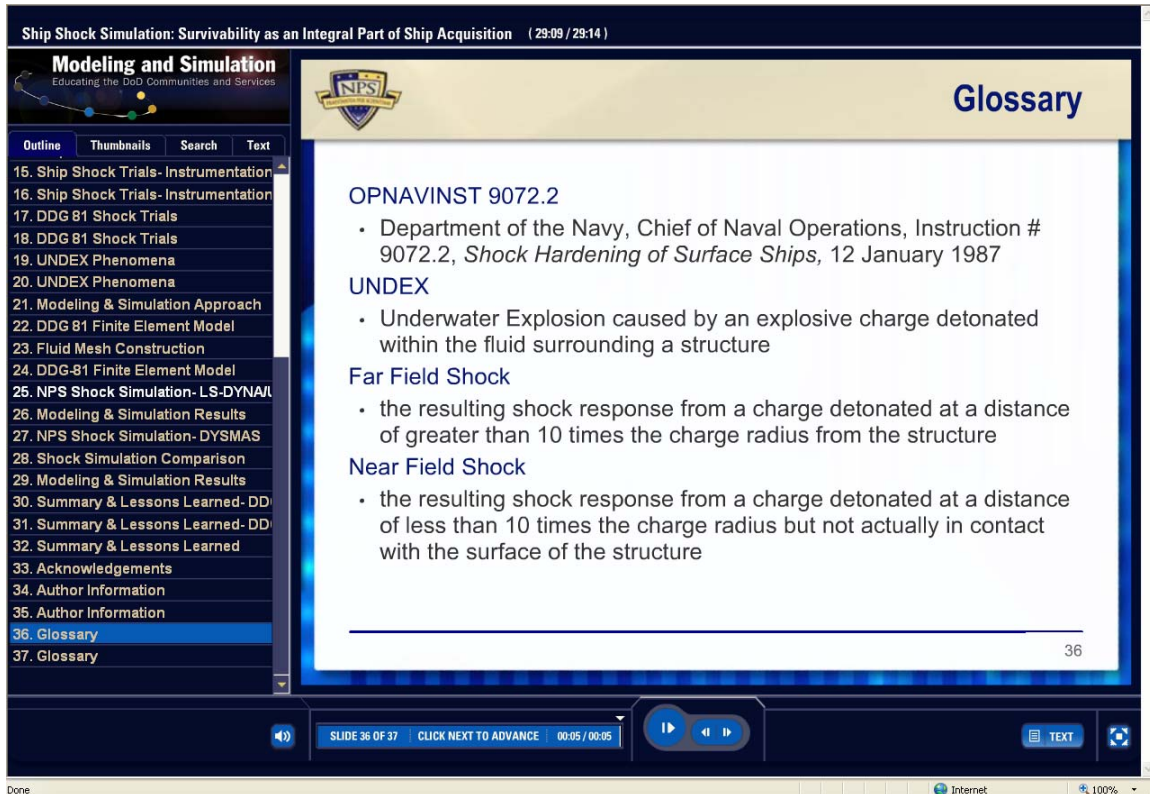


Figure 2.5.6. Screen Shot Depicting Linked Glossary Terms

In addition to the web-based content, formal papers were written for each of the engineering case studies. These documents provide greater detail and will be provided for reference as a bound edition once editing is complete. A sample of one of these documents, "Life Limiting Damage in Railguns: Role of Modeling & Simulation in Root Cause Analysis, Design and Acquisition" prepared by Professors Indranath Dutta and Sarath Menon, is presented here in draft form. The accompanying web-based version of the case study may be accessed via the link provided here

[https://diana.nps.edu/MSAcq/Case\\_Studies/Case\\_studies.htm](https://diana.nps.edu/MSAcq/Case_Studies/Case_studies.htm).

The final versions of the web-based learning tools are still in production and should be ready for release January 2008. Once complete, the entire library of engineering case studies will be available at the above link. Currently four examples are posted. A printed case study edition will also be available under separate cover.

# Life - Limiting Damage in Railguns: Role of Modeling & Simulation in Root Cause Analysis, Design and Acquisition

I. Dutta and E. S. K. Menon

Department of Mechanical and Astronautical Engineering  
Naval Postgraduate School, Monterey, CA 93943

## Executive summary

The US Military has invested substantial resources in the design, development and acquisition of Electromagnetic Railguns for use on board future electric ships. Current railgun designs are plagued by severe reliability and lifespan limitations. This case study uses engineering analyses to address the following:

- (1) identify the key mechanism limiting railgun life
- (2) present a root cause analysis of this mechanism, and
- (3) propose a possible design solution.

This case study demonstrates how modeling and simulation may be utilized to (1) predict emerging problems in future engineered systems, and (2) develop engineering solutions which may be incorporated into design specifications during the acquisition process.

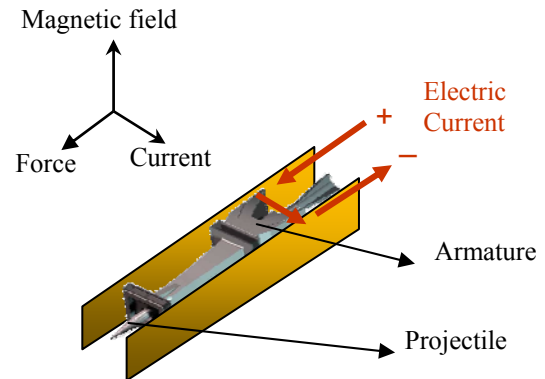
## Table of contents

1. What is an Electromagnetic Railgun?
2. Engineering, DoD & Acquisition Relevance
3. Engineering Analysis Approach
4. Detailed Investigation & Results
  - Failure analysis (experimental)
  - Root cause analysis (M&S)
  - Potential solution (M&S)
5. Summary of technical results
6. Acknowledgements
7. References
8. Author Information
9. Glossary

### 1. What is an Electromagnetic Railgun?

A railgun is a form of gun that converts electrical energy (rather than chemical energy from an explosive propellant) into projectile kinetic energy. Unlike gas pressure guns, rail guns are not limited by the speed of sound in a compressed gas, so they are capable of accelerating projectiles to extremely high speeds, typically reaching 2km/s or higher (Wikipedia). **Figure 1** is a schematic diagram illustrating the operating principle of a railgun where current is passed through two Cu rails and the conducting armature (that houses a projectile) completes the electrical circuit. As electrical current runs up the positive rail and to the negative rail through the armature, magnetic field is created around the current carrying copper rails and a net magnetic force is directed vertically while the projectile experiences a Lorentz force in a direction perpendicular to both the magnetic field

and the current flow. Application of 1 – 5 Million amperes would achieve a high muzzle velocity of ~2.5 km/sec and a long strike range of 300 – 400 nautical miles.



**Figure 1:** Schematic diagram explaining the principle of operation of a railgun

### 2. Engineering, DoD & Acquisition Relevance

The development of electromagnetic launcher (EML) technology has recently received significant attention owing to its potential applications in military and aerospace programs. One of the most promising applications of EML technology is railguns, which can achieve velocities up to 2000 meters per second. Such velocities are considerably above those normally achieved in traditional propellant guns and thus provide greatly increased armor penetration. Railguns are of particular interest to DoD as an alternative to large artillery and the ability to use small non-hazardous projectiles that are easier to handle, transport and store aboard ships in comparison to current artillery offers additional relevance especially to US Navy. Navy's next generation surface combat ships, all-electric DD(X) will be able to divert power from the propellers to the railgun. Due to their higher velocities, the missiles are also less susceptible to bullet drop and wind shift as in current artillery shells. The key advantages of rail guns can be summed up as: (a) long range (>200 Nautical Miles) (b) hypervelocity launch (>2.5km/s) (c) high directed lethality (c) low-signature (no gun propellant) (d) exploits excess power in all-electric warships. In spite of the stated advantages of railguns, in reality, several engineering problems plague the use of railguns. The generation of required power poses a great challenge. The intense heat generated due to resistive heating of the rails can cause surface melting of rails and severe damage to armature

and rail. The repulsive force generated due to the flow of current in opposite directions in the two rails is significant and tends to push the rails apart.

The damages during each round of firing severely limits the life of rails to only 50 – 100 rounds instead of the desired 1000 or more. The damage results from the interaction between a host of complex processes which include, but are not limited to, friction, Joule heating, localized melting of the armature and associated gouging of the rails, chemical reactions at the rail-armature interface, and arcing across the rail-armature interface. During each shot, the pulsed current applied to the rails, which typically lasts a few milliseconds, streams into armature, creating an electromagnetic force (Lorentz force), which propels the armature. However, the applied current is not uniformly distributed through the cross-sections of either the rail or the armature due to the combination of (a) the skin-effect associated with the application of a high frequency or short duration pulse, which concentrates the current in the rail and the armature to thin surface skins, primarily on the inner surfaces of the rails and the rear surface of the armature; and (b) the velocity skin effect (VSE) associated with the high launch velocity, which further concentrates the current in the armature to a skin along its rear surface in addition to exaggerating the skin effect in the rail. Experience with railguns have clearly shown that rails are covered with debris during firing and during successive firing the buildup eventually causes them to spall off and the rail is severely scoured. A clear understanding of the source of debris generation is required so that necessary material as well as design solutions can be incorporated in future.

### 3. Engineering Analysis Approach

Railgun technology is currently in R&D stage. The DoD is awarding contracts to fabricate, test and refine prototypes of railguns to commercial ventures. For the Navy to award R&D contracts to commercial firms, it is necessary to determine which designs incorporate reliable solutions to key problems that have been identified as earlier. For this, it is necessary that the Navy has capabilities for Root Cause Analysis (RCA) of key life-limiting issues for railguns. Once RCA is done, it is critical that potentially viable solutions are culled from the plethora of proposed solutions. These goals are accomplished by judicious use of modeling and simulation studies in identifying the key parameters and their relative role in railgun failures and hence offer creative and economic solutions to the problems. A detailed report on an example case study conducted in our laboratory is discussed here.

### 4. Detailed Investigation & Results

This case study examines one key cause of limited railgun life and proposes a possible design solution to produce longer lasting guns. The approach consisted of (a) detailed failure analysis involving the use of analytical tools for an experimental characterization of the debris and follow the

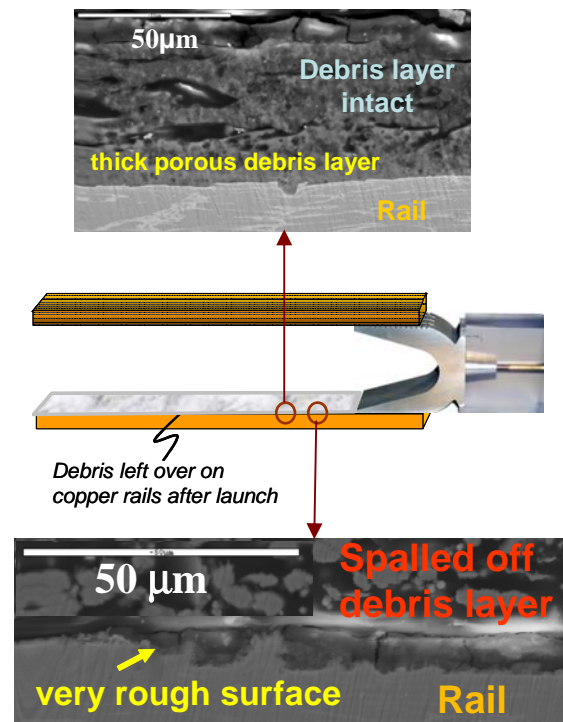
path of its origin (b) use of finite element techniques to model and simulate the role of various metallurgical and design parameters to understand the origin of debris deposition and damage and (c) identification of potential technical solutions to aid the US military in acquisition and contract awarding process.

#### **Failure analysis (Experimental)**

In order to study the metallurgical effects of railgun damages, segments of the rails were prepared for Microstructural examination using optical and scanning electron microscopy techniques and the results of these experiments are discussed in the following subsections.

##### A. Microstructural Analysis of Rail-Surfaces

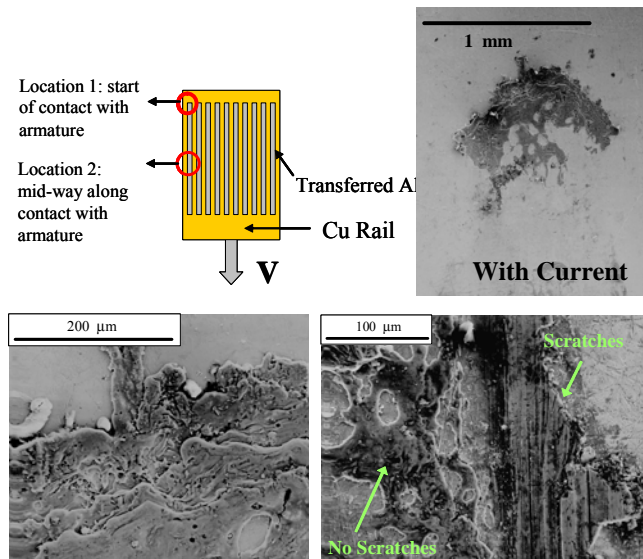
In order to study the metallurgical effects of current crowding in the armature, and the associated damage to the rails in a systematic manner, a novel experiment, based on two identical and rigidly attached C-shaped armatures, traveling between two separate and electrically isolated sets of rails was conducted, as shown in **Figure 2** (middle). A current pulse of 100kA of a few millisecond duration was passed through one set of rails, which electromagnetically propelled the armature. Following the launch, significant deposits of debris were noted on the rail, as shown the top and bottom scanning electron micrographs which shows the thick and porous layer left on the rail surface..



**Figure 2** Secondary electron images showing debris left on the Cu rails



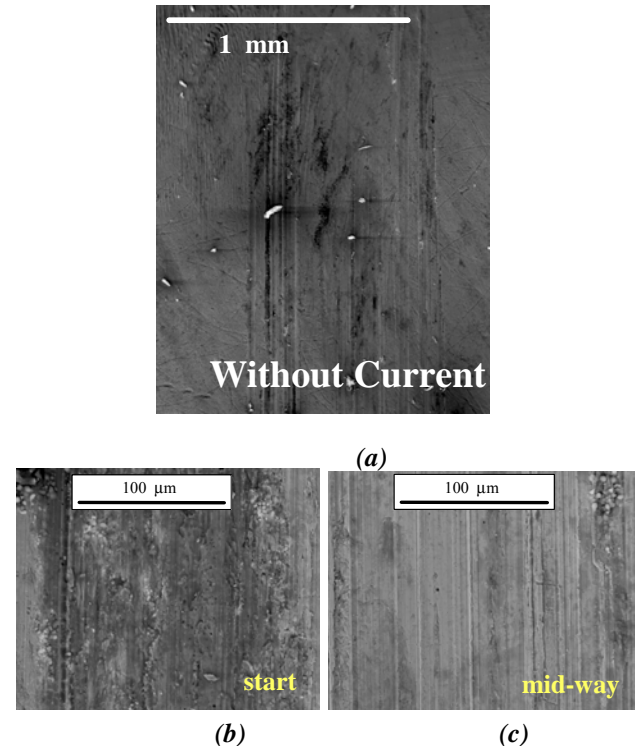
Significant amounts of aluminum were present on these rails, corresponding to the lamina of the armature which contacted the rail, as shown schematically in **Figure 3a**. The deposits due to the current carrying armature were substantially greater than those due to the non-current carrying armature. **Figure 3b** shows a secondary electron image of the rail surface at the beginning of armature contact with the rail for the armatures with current. As suggested by the shape of the deposit in **Figure 3b**, the current-carrying armature undergoes localized melting, thereby depositing molten aluminum on the rail at the very start of travel. A higher magnification micrograph of the thick, molten Al deposit on the Cu rail is shown in **Figure 3c**. Because of the lubrication provided by the melt, no scratches are observed at the beginning of the armature travel. However, a short distance away from the start, evidence of scratches appears on the rail surface in regions with limited melt-deposition, as shown in **Figure 3d**. With travel, the melt-deposition decreases, along with a corresponding increase in the extent of scratching on the rail.



**Figure 3:** (a) Schematic of the rail with stripes of Al deposits left by the current-carrying armature after firing at velocity  $V$ . (b & c) Low and high magnification SE micrographs at the start of armature/rail contact evidencing substantial melting but no scratches. (d) SE micrograph mid-way along armature/rail contact showing both melting and scratching. The armature traveled from top to bottom in the paper plane.

In contrast, the armature without current shows evidence of scratching right from the start, as shown in **Figure 4a**, which shows the topography of the rail at the beginning of travel. In addition to the scratch-marks which are prolific, some discontinuous, particulate-shaped Al deposits are also noted, although this is very limited, and there is no evidence of melting, as seen in the higher magnification picture in **Figure 4b**. It is inferred that these

deposits occur due to frictional welding and shearing as the asperities on the armature slide past those on the rail during travel. Further along the travel path, only scratches are observed, with negligible amounts of Al deposits, as observed in **Figure 4c**.



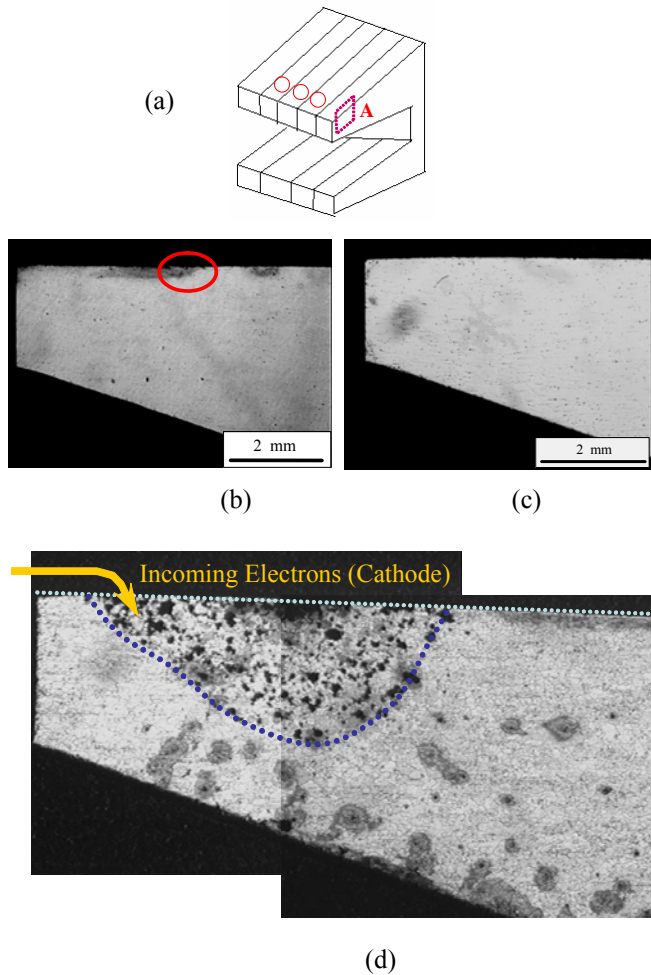
**Figure 4:** (a) Low magnification SE micrograph showing extensive scratching on rail in contact with the non-current carrying armature. (b & c) Higher magnification micrographs showing both scratches and solid Al deposits, many in particulate form, at the beginning of armature travel, and only scratches mid-way along the travel.

## B. Microstructural Analysis of Armature

### (i). Microstructure of Joule Heat Affected Zone (JHAZ)

The macro- and microstructures of the armatures with and without current were inspected using optical microscopy and SEM at the locations shown in the schematic in **Figure 5a**. Examination of the surfaces of the armature where it contacted the rail showed distinct signs of localized melting at the trailing-end of the armature with current, on both the current entry and exit sides. As shown in **Figure 5b**, the molten zones were found only on the laminae (or layers) of the laminated armature where it contacted the rail. In contrast, the armature without current showed no evidence of localized melting (**Figure 5c**). Inspection of the polished and etched cross-sectional profile of one of the layers of the armature revealed a hemispherical heat-affected zone, where either complete or partial melting followed by resolidification occurred during launch (**Figure 5d**). No such molten zone was found in the armature without current. It

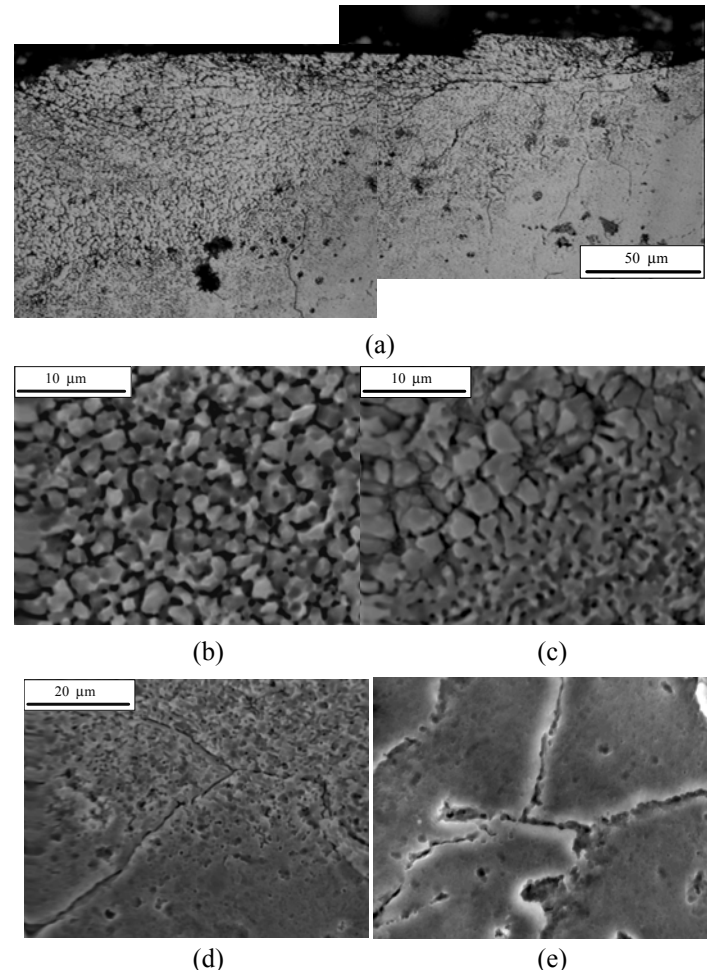
should be noted that since the rails in each armature-rail set are parallel, and the contact surfaces in both sets were subjected to uniform applied pressure, the frictional damage at the contact surfaces.



**Figure 5:** (a) Schematic of laminated Al armature showing locations of microstructural observations. (b & c) Macrographs of armatures with and without current, respectively, in lightly etched condition, revealing the presence of a heat-affected zone in the armature with current (b), but not in the armature without current (c). (d) Micrograph of another lamina of the current carrying armature in a heavily etched condition, showing a large, hemispherical Joule heat-affected zone.

for each rail-armature system should be uniform. However, as seen in Figure 6, a localized fusion zone was observed only at the trailing edge of the current-carrying armature. Furthermore, all the laminae of the current-carrying armature displayed this fusion zone, at approximately the same distance from the trailing edge. And although the contact surfaces of the current-carrying armature are subjected to an additional normal pressure due to the Lorentz force, this increased pressure (and the associated increase in friction) is

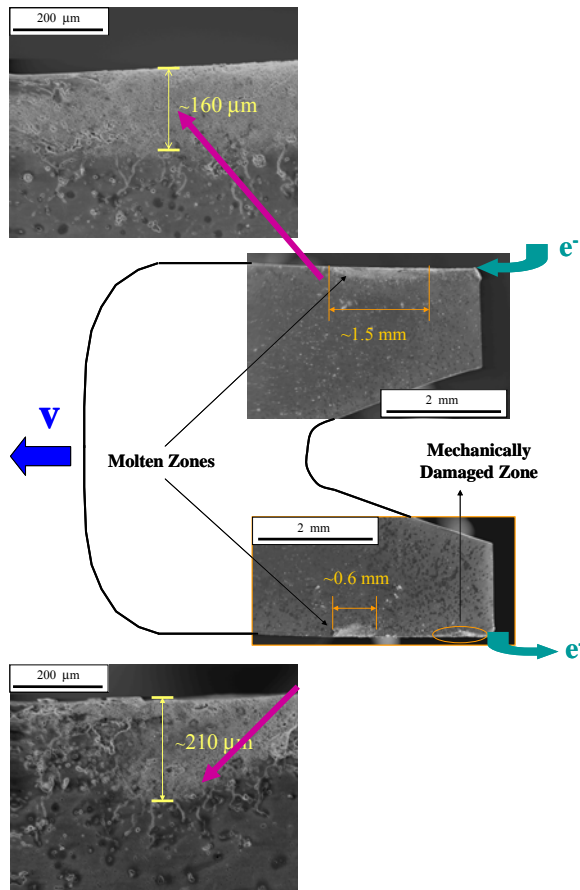
expected to be either uniform throughout a contact surface, or be maximum at the trailing edge (since the rear of the C-shaped armature would tend to open up more due to the Lorentz force). This suggests that the observed melting which is near, but appreciably displaced from the trailing edge, is not attributable to frictional effects, but rather, is caused by Joule heating due to the applied current. The localization of melting occurs due to current-crowding as the current transitions from the Cu rail to the Al armature, as will be discussed subsequently.



**Figure 6:** Microstructures in the JHAZ. (a) Overall view of part of the JHAZ, showing a fine-grained fusion zone, surrounded by a coarse grained parent metal zone. (b) Fine equiaxed grains (~2-3μm) form deep inside the JHAZ following melting and re-solidification, bordered by a chill-cast zone of less than 1μm grains (c). Outside the fusion zone, only precipitates melt, either intragranularly (d) or intergranularly (e).

Figures 6a-e show details of the microstructure within the Joule heat-affected zone (JHAZ). Figure 6a shows a low magnification micrograph of the trailing-end of the JHAZ, within which a gradation of microstructures exists. Deep within the JHAZ, a fine

equiaxed grain structure ( $\sim 2\text{-}3\mu\text{m}$ ) is observed (**Figure 6b**), suggesting that this is where the Al armature underwent complete melting and then re-solidified quickly as the current pulse trailed off during the launch. Just below it, near the edge of the molten zone, an even finer equiaxed grain structure ( $<1\mu\text{m}$ ), suggesting a chill-cast zone, is observed, as shown in **Figure 6c**. This chill-cast zone forms due to rapid heat transfer through the unmelted region which lies immediately adjacent to it. Outside the fusion zone, a coarse grain structure similar to that of the unaffected Al armature ( $\sim 50\text{-}80\mu\text{m}$ ) is noted, albeit with numerous etch-pits associated with melted and re-solidified intragranular as well as intergranular precipitates. This is shown in **Figure 6d**, where part of some of the grains and the grain boundary regions show evidence of precipitate melting, while the rest of the grain was unmelted. Farther away from the rail-armature contact, only the intergranular regions, which have high precipitate density, show evidence of melting, with no intragranular melting (**Figure 6e**). The high impurity concentration at the grain boundaries can cause the grain boundary resistivity to be several orders of magnitude higher than the bulk resistivity, thereby exacerbating the effect of Joule heating.



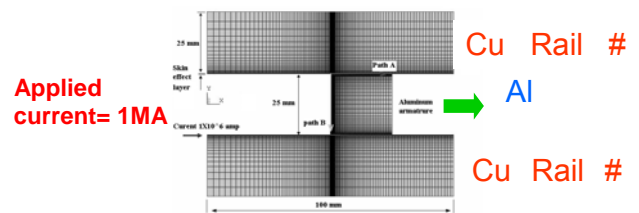
**Figure 7:** Location of melting initiation in armature

Thus, the JHAZ in the armature comprises a range of graded microstructures at different locations, depending on whether that location underwent complete or partial melting, and the associated cooling/solidification rate.

Careful examination of the armature showed clearly that melting always occurred at a location slightly removed from the trailing edge of the armature. This is shown in **Figure 7**. The molten regions are indicated in the micrographs and the location indicated.

#### **Root cause analysis (Modeling & Simulation)**

A simplified two-dimensional (2-D) electrical-thermal model was created by using the commercial finite element software, ANSYS, representing the armature as a stationary square aluminum block between two copper rails, as shown in **Figure 8**. The skin effect in the rail was simulated by introducing an artificial conductive skin layer of desired thickness (either  $100\mu\text{m}$  or  $1\text{mm}$ ) on the surfaces of the rails in contact with the armature, while the rest of the rails were assumed to be electrically non-conductive. Therefore, the applied current passed only through the skin layers on the two copper rails, allowing simulation of the effects of both the pulse-induced and velocity skin effects in the rail. The velocity skin effect in the armature, which is thought to be less severe, was ignored in the model. A square current pulse of  $10\text{ms}$  duration and peak current of  $1 \times 10^6\text{ A}$  was applied to the rail, allowing computation of the spatial current density ( $j$ ) and temperature ( $T$ ) fields. The material properties used in the model are values for Al and Cu. All external surfaces of the model were assumed to be subject to convection heat transfer only, since radiation losses are likely to be negligible in the time-scales of interest.

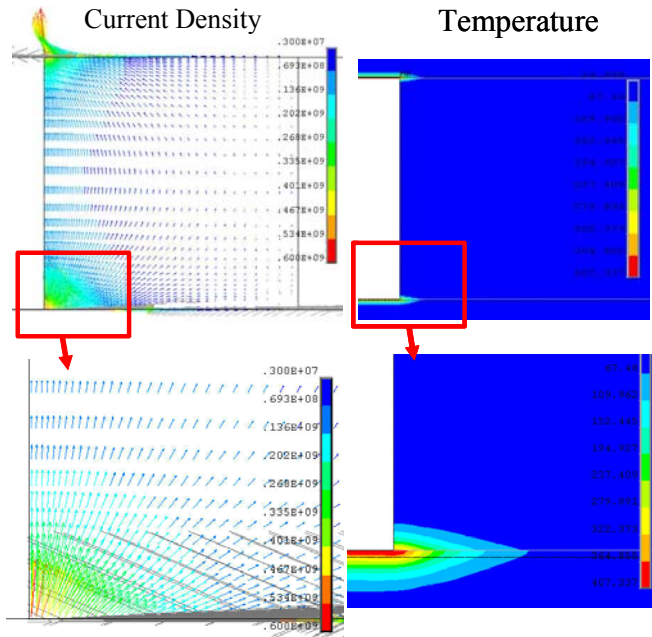


**Figure 8:** A simplified two dimensional stationary but transient thermal-electrical model of the rail-armature system, showing a skin layer on the inner rail surfaces, which carry the entire rail current. The current enters the armature from the bottom rail and exits into the top rail.

The impact of the quality of armature-rail contact was assessed by systematically varying the electrical contact conductance  $C_c$  (expressed as conductance per unit area,  $\Omega^{-1}\text{m}^{-2}$ ) of the armature-rail interface, and the skin depth ( $\delta$ ). The  $C_c$  values were varied on both sides of the range of available values for typical metal-to-metal contacts, over a range of  $\sim 10^7$  to  $10^9\ \Omega^{-1}\text{m}^{-2}$ , along with two extreme values of  $10$  and  $10^{13}\ \Omega^{-1}\text{m}^{-2}$ . The skin depth  $\delta$  was assumed to be either  $100\mu\text{m}$  or  $1\text{mm}$ .

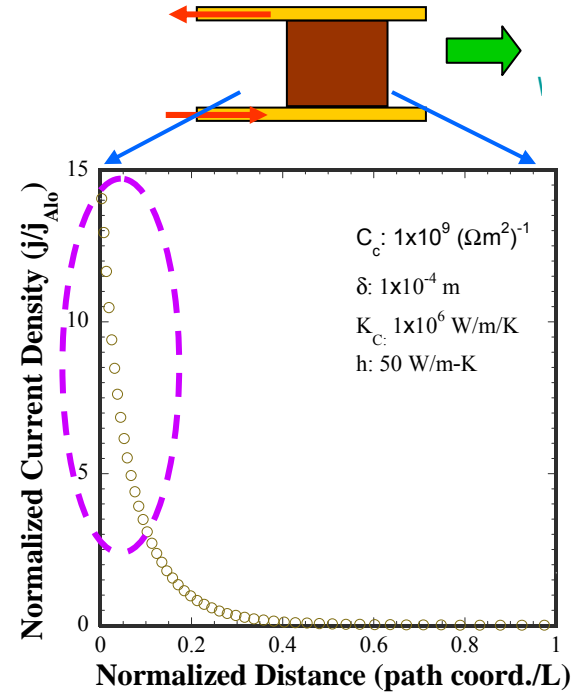


Additionally, the thermal contact conductance of the rail-armature interface ( $K_c$ ), and the convection coefficient ( $h$ ) on the external surfaces of the system, were also varied parametrically in order to assess their effect on the current density and thermal profiles. However, it was found that because of the very short time-scales involved, the impact of the thermal parameters is negligible, and therefore, the results reported in this paper are all based on  $h=50\text{W/m}^2\text{K}$  and  $K_c=106\text{W/m}^2\text{K}$ .



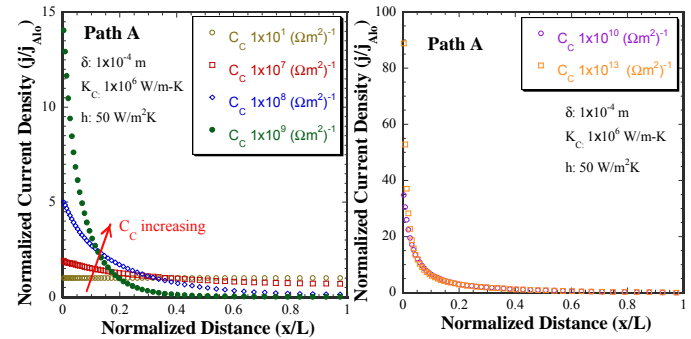
**Figure 9:** Vector plot of current density distribution within the armature (a), and associated temperature distribution (b) for  $C_c=1 \times 10^9 (\Omega\text{m}^2)^{-1}$ ,  $\delta=1 \times 10^{-4}\text{m}$ ,  $K_c=1 \times 10^6 \text{ W/m}^2\text{K}$ , and  $h=50\text{W/m}^2\text{K}$ . (c) and (d) show enlarged views of the  $j$  and  $T$  distributions at the rail-armature interface where the current enters the armature, showing both current and temperature concentrate heavily at the initial point-of-entry.

**Figure 9** shows the distributions of current density ( $j$ ) and temperature ( $T$ ) within a block-shaped armature of square cross-section. From **Figures 9a** and **9b**, it is observed that there is significant current-crowding at the points of current entry into, and exit from, the armature, associated with which there is a substantial temperature-rise. Both the current density and temperature distributions are symmetric about the horizontal mid-plane of the armature. **Figures 9c** and **9d**, which show enlarged views of the region of current entry, reveal that the maximum current density can be nearly an order of magnitude greater than the minimum current density, with the region of maximum temperature correlating well with the maximum current density. **Figure 10** shows the variation of current density along the length of the armature as calculated. From this plot, it can be seen that there is a huge current crowding and an associated large temperature increase at the trailing edge of the armature. **Figure 11** plots



**Figure 10:** Huge current crowding at the trailing edge of armature.

the current density normalized by the mean armature current density ( $j/j_{Alo}$ ) against the normalized distance ( $x/L$ ) along the rail-armature interface (path A in **Figure 8**), where  $L$  is the length of the armature. It is seen that the current concentrates

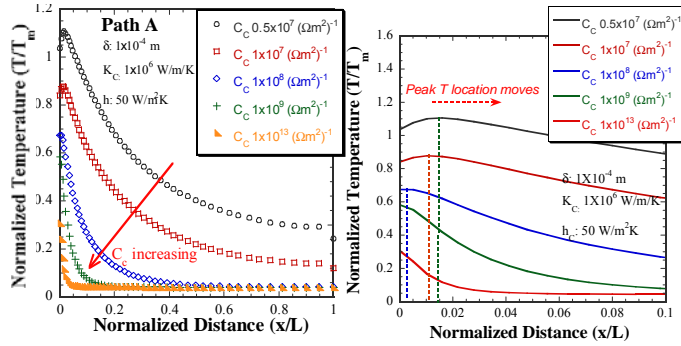


**Figure 11:** Plots of normalized current density ( $j/j_{Alo}$ ) along the armature-rail contact (path A in **Figure 8**), showing the effect of interfacial contact conductance  $C_c$ . Current crowding increases with increasing  $C_c$ , with the maximum value of  $j/j_{Alo}$  being  $\sim 1$  at  $C_c=1 \times 10^5 (\Omega\text{m}^2)^{-1}$ ,  $\sim 15$  at  $C_c=1 \times 10^9 (\Omega\text{m}^2)^{-1}$ , and  $\sim 90$  at  $C_c=1 \times 10^{13} (\Omega\text{m}^2)^{-1}$ .

sharply at the points of current entry and exit into/from the armature, and the more the current crowds at the corners (i.e., at  $x/L=0$ ), the less the value of  $j$  far away from the corner (i.e., at  $x/L \rightarrow 1$ ). Further, as the interfacial contact conductance  $C_c$  increases, the current crowding at the points of current entry



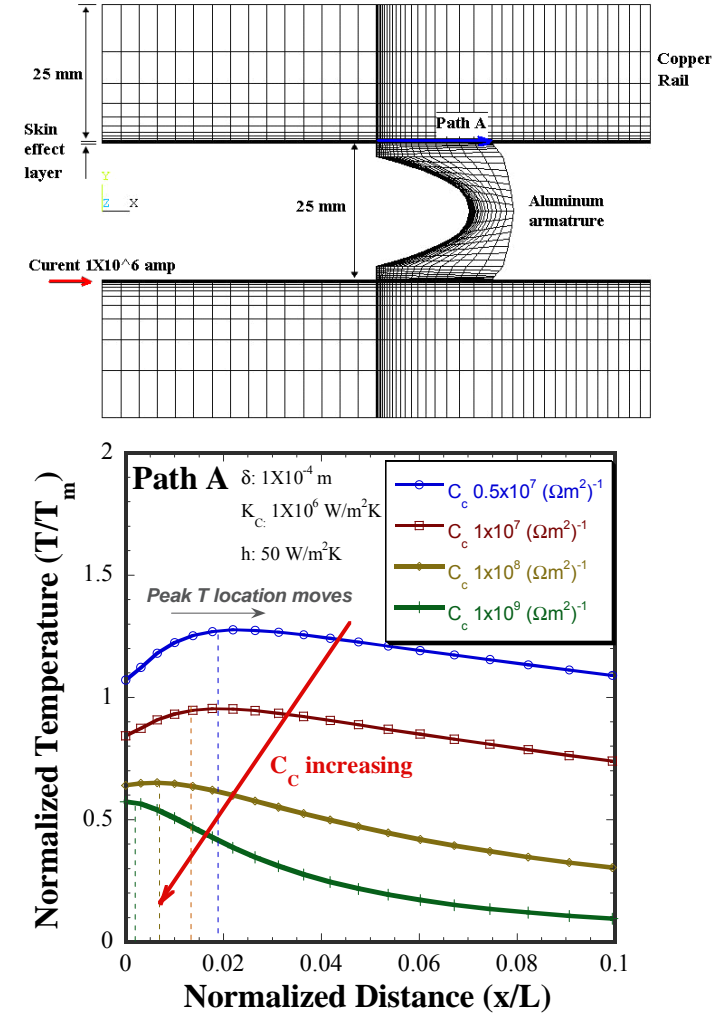
and exit also increases sharply, with the maximum value of  $j/j_{AlO}$  being  $\sim 1$  at  $C_c = 1 \times 10^9 (\Omega m^2)^{-1}$ ,  $\sim 15$  at  $C_c = 1 \times 10^8 (\Omega m^2)^{-1}$ , and  $\sim 90$  at  $C_c = 1 \times 10^{13} (\Omega m^2)^{-1}$ . These results are consistent with studies on microelectronic devices, where current crowding at the interface between thin film structures of different materials is known to increase with decreasing contact resistance, with potentially severe impact on effects such as electromigration-induced void formation.



**Figure 12:** Plots of normalized temperature ( $T/T_m$ ) along the armature-rail contact (path A), showing the effect of interfacial contact conductance  $C_c$ . With increasing  $C_c$ , the maximum temperature decreases (a), and the location of maximum temperature moves away from the corner of the rail-armature contact, i.e., from  $x/L=0$  (b).

Commensurate with current crowding, the temperature at the corners of the armature is also high relative to the armature temperature far away from the corner, as observed in **Figure 12**, which plots the armature temperature normalized by the melting point along the interface. Further it is noted that the larger the  $C_c$  and higher the current crowding, the higher is the temperature of the corner relative to the temperature far away, i.e., the ratio of  $T/T_m(x/L \rightarrow 0)$  to  $T/T_m(x/L \rightarrow 1)$  increases with increasing current crowding. However, it is also seen from **Figure 12a** that the actual value of temperature reached at the corner of the armature is lower for larger  $C_c$  values, despite the enhanced current crowding under these conditions. This is because large increases in  $C_c$  (orders of magnitude) are necessary to cause the increased level of current crowding (which commensurately increases by 2-3 times). Since the Joule heat generated at the interface depends on  $j^2/C_c$ , when an order of magnitude increase in  $C_c$  causes a doubling or trebling of  $j$ , it still causes the corner temperature to decrease. **Figure 12b** shows the normalized temperature distribution at the interface very close to the corner of the armature (from  $x/L=0$  to 0.1). It is observed that the maximum temperature occurs not at the corner, but slightly away from it. Furthermore, the lower the  $C_c$ , the further the location of the peak temperature moves from the corner of the armature-rail contact. This dependence of the peak temperature location on  $C_c$  is thought to be the reason for the fusion zone in the armature to be removed from the armature corner in **Figure 5**.

These simulations also showed that as the skin depth,  $\delta$  decreases, the extent of current crowding increases, as does the interfacial temperature. Thus for the same value of  $C_c$ , the lower the current crowding, the lower is the peak temperature achieved.

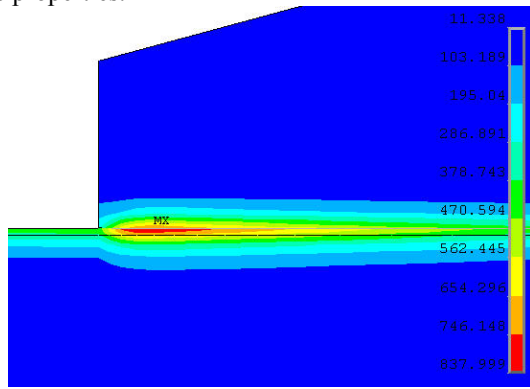


**Figure 12:** Model of a C-shaped armature used in the simulations.

It is interesting to note that in the experiments, melting did not take place immediately at the corners where the current entered/left the armature. Instead, the observed molten region was slightly shifted from the corner (by  $\sim 0.5$ -1 mm), as shown in **Figures 5 and 7**. Although this is consistent with the shift of the maximum  $T/T_m$  away from  $x/L=0$  with decreasing  $C_c$ , as noted in the model for the block-shaped armature, a model with a C-shaped armature similar to that tested experimentally was also created to investigate whether this effect is armature-shape dependent. The model and the  $T/T_m$  variation along the armature-rail interface are shown in **Figures 12**. It was found that as for the block-shaped armature, the peak temperature along the interface shifted away from the corner with decreasing  $C_c$ , as

plotted in **Figure 12**. This is because a lower  $C_c$  causes a slight delay in the passage of the current from the rail into the armature, thereby allowing the current to spread out more as it enters the armature, instead of crowding up heavily at the first point of contact between the rail and the armature. This reduction of current crowding at the corner, in conjunction with rapid heat removal from the free-surface constituted by the trailing edge, and enhanced Joule heating at the interface due to the lower  $C_c$ , makes the peak interfacial temperature shift away from the corner. And as seen from the modeling results on both block-shaped and C-shaped armatures, this trend appears to be independent of the armature geometry. Since from SEM investigation, it was found that the melt-zone is significantly removed from the corner, it may be inferred that the contact conductance  $C_c$  in the present experiments was rather low. These simulations show that (a) current concentration increases with  $C_c$  (b) the peak temperature decreases with  $C_c$  (c) the location of peak temperature shifts to right with  $C_c$ . The trends observed in the C-shaped armature was essentially similar to that of the block armature.

The location of the initiation of molten zone was also determined from the simulation results of the thermal profile and a particular case with the properties designated is shown in **Figure 13**. It can be seen that localized melting occurs with the melt zone slightly away from the trailing end of armature in excellent correlation with the experimental observations (**Figures 5 and 7**). It must be realized the exact location of the melt zone initiation would depend on the interface properties.



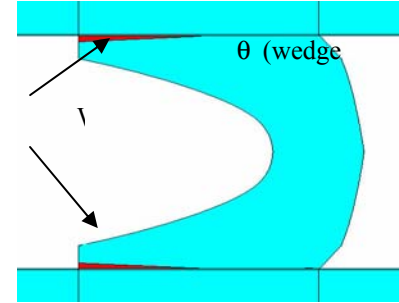
**Figure 13:** Simulated thermal profile;  $C_c = 0.5 \times 10^7 (\Omega m^2)^{-1}$ ,  $\delta = 10^{-4} m$ ,  $K_c = 10^6 (W/m^2 K)$ ,  $h = 50 (W/m^2 K)$

These results of these simulation studies show an excellent agreement with the experimental observations made in this study and described earlier.

#### Potential solution (Modeling & Simulation)

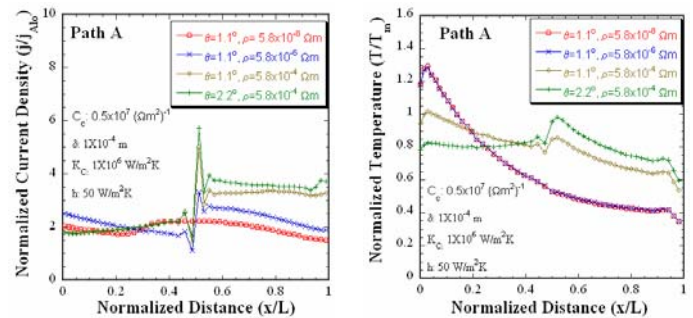
Can the simulations carried out in this example can now be judiciously used to find a potential solution to the problem of elimination (or at least substantial reduction of) debris formation? Indeed it is clear that debris formation can be

substantially reduced if local melting can be avoided which in turn can be controlled by minimizing current crowding. Consequently, simulations were carried out on models introducing a wedge-shaped interfacial layer at the armature-rail interface as shown in **Figure 13**.



**Figure 14:** Schematic of wedge-shaped interfacial layer.

The variation of current density and the temperature profile for the geometry as shown in **Figure 14** is presented in **Figure 15**. We can see that introduction of deeper wedge-shaped interfacial layer increases the current and temperature concentration at the armature-rail interface. Thus, if a properly selected wedge-shaped interfacial layer can be introduced between the armature and rail, it is possible to eliminate current crowding and localized melting. This finding offers an exciting way to redesign the interfacial region in order to substantially reduce the effect of current crowding at the armature-rail interface.



**Figure 15:** Plots of normalized current density and normalized temperature along the armature-rail contact with various wedge-shaped interfacial layers, showing the effect of wedge angle. With deeper wedges, current and temperature concentration at the corners are increased.

#### 5. Summary of technical results

An example case study of railgun failure due to severe debris formation that substantially limits the life of railguns was examined by failure analysis in combination with modeling and simulation study. A brief discussion of the methodology is provided here to illustrate the utilization of simulation results in finding potential design solutions to such a complex problem. The key findings of the case study discussed here can be summarized as follows:

- 1) Experimental work showed that
  1. Aluminum armature melts due to extreme Joule and/or frictional heating
  2. Aluminum melt deposits on rails
  3. During successive shots, debris layer grows thicker
  4. When thick debris layer spalls, rail damage occurs
- 2) Simulation studies showed that:
  1. Rail damage occurs due to Armature melting & melt deposition on rails
  2. Armature melting occurs due to current crowding at the trailing end of armature, and consequently high Joule heating
  3. Exact location of melt initiation can be controlled by controlling various material parameters
  4. Most important material parameter is interfacial contact conductance ( $C_c$ )

Here, we have also demonstrated that by changing the physical design of the interfacial region, we can reduce current crowding, possibly enhancing rail life.

## 6. Acknowledgements

1. The research work based on which these slides are compiled was supported by a MURI grant (# N00014-04-1-0599RQ-M) from ONR
2. The collaboration of Dr. Xin Long of NPS and Dr. Chadee Persad of IAT are gratefully acknowledged

## 7. References

<http://en.wikipedia.org/wiki/Railgun>

C. Persad, A. Yeoh, G. Prabhu, G. White and Z. Eliezer, "On the nature of the armature-rail interface: liquid metal effects." *IEEE Trans. Magn.*, vol.33, no.1, pp.140-145, 1997.

T. Watt and F. Stefani, "Experimental and computational investigation of root-radius melting in C-shaped solid armatures." *IEEE Trans. Magn.*, vol.41, no.1, pp.442-447, 2005.

T. Chen, X. Long, I. Dutta and C. Persad *IEEE Trans. Magn.*, vol.43, no.7, pp.3278-3286, 2007.

## 8. Author Information

Indranath Dutta is Professor of Materials Science and Mechanical Engineering and Director of the Composites, Thin Films and Interfaces Laboratory at the Naval Postgraduate School, where he is active in research and instruction in the area of thermo-mechanical behavior of multi-component materials systems. His current research focuses on materials issues in micro-systems and hypervelocity railguns, with support from NSF, ARO, ONR, SRC

and the industry. He was an AFOSR Summer Research Fellow at the Air Force Research Laboratory in 1995, Visiting Fellow at the University of Oxford in 1996, Visiting Consultant at MOTOROLA in 2000, and Visiting Faculty at INTEL Corporation in 2001. He is a recipient of several awards, including the TMS Young Leader Award, NPS Outstanding Research Achievement Award, the Carl E. and Jessie W. Menneken Award for Excellence in Scientific Research at NPS, is listed in Who's Who in the World and Who's Who in America, and is a Fellow of ASM International. Dr. Dutta serves as a consultant to several companies in the microelectronics industry

Sarath Menon is Research Professor of Materials Science and Mechanical Engineering at the Naval Postgraduate School. His current research focus is on the properties of interfaces and thin films with emphasis on understanding the fundamental mechanisms of the behavior of thin film-substrate interfaces under electrical and thermo-mechanical loading with Prof. Indranath Dutta. His area of expertise is mainly in the area of phase transformations in materials and various advanced materials characterization techniques. He has worked extensively on many structural materials including Nb-based alloys, Ti-based alloys and Ni-based superalloys in various research laboratories including the Air Force materials laboratory, Wright-Patterson Air Force Base, Los Alamos National laboratory, University of CA, Berkeley etc.

## 9. Glossary

**Spall** - Peeling off of deposited debris when debris layer becomes thick.

**Microstructure** - Structure of a material at the micrometer scale, observed through a high power microscope

**Finite element** - Finite element analysis (FEA) is a numerical technique used in engineering analysis where an object is represented by multiple, linked, discrete regions called finite elements. Equations of equilibrium are applied to each element, and a system of simultaneous equations is constructed and solved to obtain the response of the object to external stimuli.

**Skin effect / skin depth** - When a high frequency alternating current or a very short current pulse passes through a conductor, the current concentrates only in a thin layer on the conductor surface. This is called "skin effect", and layer thickness is "skin depth".

**Interface** - A surface at which two different objects contact each other. For instance, the contact surface between the rail and the armature is referred to as the armature-rail interface.

**Electrical contact conductance** - Electrical conductivity of an interface between two objects. It is a measure of the ease with which current can pass from one object to another through the interface.

## **2.6 Acquisition Manager's Guide to Modeling and Simulation**

### **Outline**

**Produced in support of the Modeling and Simulations Education for the Workforce  
By  
The Naval Postgraduate School**

**Naval Postgraduate School  
Monterey, California**

**2008**

In April 2006, the Acquisition Modeling and Simulation Working Group released the *Department of Defense Acquisition Modeling and Simulation Master Plan*. The actions outlined in the master plan were designed to “foster widely-needed M&S capabilities beyond the reach of individual programs; better enable acquisition of effective joint capabilities and systems-of-systems; empower program and capability managers by removing systemic M&S obstacles, indentifying new options for approaching tasks, and helping support widely-shared needs; and promote coordination and interface with M&S activities of the DoD Components.”<sup>1</sup>

The Naval Postgraduate School led a multi-university effort to provide education and training options that will enhance the acquisition workforce’s ability to apply modeling and simulation tools, ultimately augmenting warfighting capability while reducing lifecycle development time and costs. This guidebook is part of a larger effort to expand modeling and simulation education for the acquisition workforce. The purpose of the guidebook is to assist the acquisition professional in the use of M&S throughout the life cycle. The guidebook serves as an updated replacement for the 1994 *Systems Acquisition Manager’s Guide for the use of Models and Simulations*. Methodologies used in the guidebook are the selection of key areas of importance to M&S professionals through consultation and vetting the document within the M&S community.

The following outline specifies the key areas covered in the guidebook. The outline reflects careful consideration of topics to aid in an acquisition professional’s decision making as related to M&S. The introductory chapter discusses the current state of M&S in Acquisition. In addition, the introduction covers the JCIDS process in depth

---

<sup>1</sup> Office of the Undersecretary of Defense (Acquisition, Technology and Logistics) Defense Systems. *Department of Defense Acquisition Modeling and Simulation Master Plan*, April 17, 2006, 7.

and presents the goals and objectives of the guidebook. A selected bibliography included in this outline indicates source material used in the development of the guidebook. Each of the following numerals denotes chapters that will appear in the guidebook, while subheadings denote sub-topics.

## I. M&S in the Acquisition Life Cycle

- a. Background
- b. Brief history of M&S
- c. Today's Applications
- d. Reform

## II. M&S Requirements

- a. Organization and Policy
- b. Hierarchy of Modeling and Simulations
- c. Evaluating M&S Proposals
- d. Contracting for M&S
  - i. Cost Engineering

## III. Management of Modeling and Simulation

- a. Planning for Modeling and Simulation Effort
- b. Models and Simulations as Contract Deliverables
- c. Standards for Reuse

## IV. Modeling and Simulations in Support of Acquisition

- a. Credibility of M&S
- b. Standards for M&S
- c. Simulation Support Plan (SSP)

## V. Verification, Validation and Accreditation (VV&A)

- a. VV&A Policy
- b. Cost

- c. Important References
- VI. The Future of Modeling and Simulation
- VII. Common Issues in M&S
  - a. Intellectual Property
  - b. Unarticulated Business Model
  - c. Repository
- VIII. References and Bibliography
- IX. Appendix A—Glossary
- X. Appendix B—DoD Sources of Information for M&S in Weapons Systems Acquisition
- XI. Appendix C—Department of the Army M&S Resources
- XII. Appendix D—Department of the Navy M&S Resources
- XIII. Appendix E—Marine Corps M&S Resources
- XIV. Appendix F—Department of the Air Force M&S Resources
- XV. Appendix G—Additional Resources
  - a. Case Studies
  - b. Educational Development and Resources
  - c. Professional Memberships
- XVI. List of Figures
- XVII. List of Tables



## SELECTED BIBLIOGRAPHY

This bibliography represents the books and articles that proved useful in the creation of the guidebook. This bibliography is by no means a complete record of all of the works consulted. This bibliography gives a broad overview of the areas covered in the guidebook. This bibliography is intended to be useful to readers interested in pursuing further study in the area of Modeling and Simulation.

Adamy, David. 2003. *Introduction to Electronic Warfare Modeling and Simulation*. Boston, MA: Artech House, 2003.

Air Force Research Laboratory, "Success Stories: A Review of 2000," Air Force Research Laboratory: Wright-Patterson Air Force Base, Ohio, August 27, 2001.

Air Force Research Laboratory Materials and Manufacturing Directorate, "Toward More Affordable Defense Technology: IPPD [Integrated Product and Process Development] for S&T [Science and Technology] Quick Reference," published 1999 by James Gregory Associates Inc.

Aitcheson, Leslie, Ballistic Missile Defense Organization Technology Applications Program, "Technology Commercialization: How Is It Working for BMDO?" *The Update*, Summer/Fall 1998, pages 1, 12, 13.

Aitcheson, Leslie, "Cashing in the Chips: BMDO Technology Is Making Big Payoffs for Semiconductor Producers," *BMDO Update*, Summer 2000, Issue #34, pages 1-3.

Aldridge, Edward C., Under Secretary of Defense for Acquisition, Technology, and Logistics; and Delores M. Etter, Deputy Directory, Defense Research and Engineering, "Technological Superiority for National Security," statement before the Senate Armed Services Committee, Emerging Threats and Capabilities Subcommittee, Defense Wide Research and Development, June 5, 2001.

Aldridge, Edward C., Under Secretary of Defense for Acquisition, Technology, and Logistics, "Intellectual Property," Memorandum, December 21, 2001.

American Association for the Advancement of Science, "Guide to R&D Data—Historical Trends in Federal R&D (1955-)" <http://www.aaas.org/spp/dspp/rd/guihist.htm>.

American Institute of Physics, "Recommendations of Hart-Rudman National Security Report: R&D," *FYI: The AIP Bulletin of Science Policy News*. Number 22: February 28, 2001. Available at <http://www.aip.org/enews/fyi/2001/022.html>.

Ballistic Missile Defense Organization, "The 2000 BMDO Technology Applications Report: Technology, Working for You Now," National Technology Transfer Center-Washington Operations: Alexandria, Virginia, June 2000.

- Ballistic Missile Defense Organization, "Ballistic Missile Defense Organization 1998 Technology Applications Report," BMDO Office of Technology Applications: Alexandria, Va.
- Ballistic Missile Defense Organization Technology Applications Program, "Commercialization Is a Continuous Process," *BMDO Update*, Winter 2001/2002 Issue #40.
- Ballistic Missile Defense Organization Technology Applications Program, "White LEDs Illuminate a New Lighting Path: Wide-Bandgap Semiconductors Are Revolutionizing General Lighting," *BMDO Update*, Winter 2000/2001 Issue #36, pages 1-3.
- Banks, Jerry. (ed.) *Handbook of Simulation: Principles, Methodology, Advances, Applications and Practice*. New York: Wiley, 1998.
- Bhattacharyya, Shuvra S., Ed F. Deprettere, and Jürgen Teich. *Domain-Specific Processors : Systems, Architectures, Modeling, and Simulation*. Signal processing and Communications, New York: Marcel Dekker, 2003.
- Board on Manufacturing and Engineering Design (BMED). *Modeling and Simulation in Manufacturing and Defense Acquisition: Pathways to Success*. Washington D.C.: National Academy Press, 2002.
- Borck, James R., "Disruptive Technologies: How to Snare an 800-Pound Gorilla: Stun him with a disruptive technology and watch as he stumbles to adapt," *InfoWorld*. January 7, 2002, vol. 24, issue 1.
- Bureau of National Affairs Inc., "Bush Signs Executive Order Creating Science, Technology Advisory Council," *Federal Contracts Report*. Volume 76, Number 13. October 9, 2001.
- Chairman of the Joint Chiefs of Staff, "Requirements Generation System," Instruction 3170.01B, April 15, 2001. [http://www.dtic.mil/doctrine/jel/cjcsd/cjcsi/3170\\_01b.pdf](http://www.dtic.mil/doctrine/jel/cjcsd/cjcsi/3170_01b.pdf).
- Chairman of the Joint Chiefs of Staff, "Joint Vision 2020," available at <http://www.dtic.mil/jv2020/jvpub2.htm>.
- Chong, K. P. *Modeling and Simulation-Based Life Cycle Engineering*. Spon's structural engineering mechanics and design series. London ;; New York: Spon Press, 2002.
- Cloud, David J., and Larry B. Rainey. *Applied Modeling and Simulation : An Integrated Approach to Development and Operation*. Space technology series. New York: McGraw-Hill, 1998.
- Committee on Integration of Commercial and Military Manufacturing in 2010 and Beyond, Board on Manufacturing and Engineering Design, Division on Engineering

and Physical Sciences, National Research Council, "Equipping Tomorrow's Military Force: Integration of Commercial and Military Manufacturing in 2010 and Beyond." Washington, D.C.: National Academy Press, 2002.

Coyle, Philip E. III, "Evolutionary Acquisition: Seven Ways to Know If You Are Placing Your Program at Unnecessary Risk," *Program Manager*. November-December 2000.

Davis, Paul K., Amy E. Henninger, National Defense Research Institute (U.S.), and Rand Corporation. *Analysis, Analysis Practices, and Implications for Modeling and Simulation*. Occasional paper; OP-176-OSD. Santa Monica, CA: RAND Corporation, 2007.

Davis, P.K., and R. Hillestad. *Exploratory Analysis for Strategy Problems with Massive Uncertainty*. Santa Monica, CA: RAND, 2000.

DeCorpo, Jim, Chief Technology Officer of the Navy, "Rapid Technology Transitions into USN/USMC Acquisition Programs," ASN Testimony 2001.

Defense Contract Audit Agency, "Independent Research and Development and Bid and Proposal Costs Incurred by Major Defense Contractors in the Years 1998 and 1999," December 2000.

Defense Systems Management College, *Introduction to Defense Acquisition Management*, Fifth Edition, January 5, 2001.

Defense Technical Information Center, "Your Mark Will Make a Difference Down the Road! A Quick Reference for Marking DoD Documents," September 2000.

Department of Defense, "The Defense Acquisition System," DoDD 5000.1. October 23, 2000, with Change 1, January 4, 2001.

Department of Defense, "Mandatory Procedures for Major Defense Acquisition Programs (MDAPs) and Major Automated Information System (MAIS) Acquisition Programs," DoD 5000.2-R. April 5, 2002.

Deputy Under Secretary of Defense (Advanced Systems and Concepts), "Fiscal Year 2003 Advanced Concept Technology Demonstration (ACTD) Proposals," October 30, 2001.

Deputy Under Secretary of Defense (Science and Technology), "Joint Warfighting Science and Technology Plan." Washington, D.C.: February 2000.

Deputy Under Secretary of Defense (Science and Technology), Office of Technology Transition, *Dual-Use Science and Technology Process: Why Should Your Program Be Involved? What Strategies Do You Need to Be Successful?* July 2001.  
<http://www.dtic.mil/dust>.

Deputy Under Secretary of Defense (Science and Technology), “Technology Transition for Affordability: A Guide for S&T Program Managers,” April 2001.

DeSimone, L.D., Chairman of the Board and Chief Executive Officer, 3M, “Intellectual Capital: The Keystone to Competitiveness,” 1999.

Digital System Resources Inc., “Innovation in Defense Systems,” Statement of Mr. Richard Carroll, Founder and CEO, Digital System Resources Inc., to House Armed Services Committee, Military Research and Development Subcommittee, Washington, D.C., March 22, 2001.

Digital System Resources Inc., “Toward Greater Public-Private Collaboration in Research & Development: How the Treatment of Intellectual Property Rights Is Minimizing Innovation in the Federal Government,” Statement of Mr. Richard Carroll, Founder and CEO, Digital System Resources Inc., to House Committee on Government Reform, Subcommittee on Technology and Procurement Policy, U.S. House of Representatives, Washington, D.C., July 17, 2001.

Doebelin, Ernest O. *System Dynamics : Modeling, Analysis, Simulation, Design*. New York: Marcel Dekker, 1998.

DSB (Defense Science Board). Report of the Defense Science Board Task Force on Advanced Modeling and Simulation for Analyzing Combat Concepts in the 21<sup>st</sup> Century. Washington D.C.: Office of the Under Secretary of Defense for Acquisition and Technology, Department of Defense, 1999.

DTSE&E (Director for Test, Systems Engineering and Evaluation). Study on the Effectiveness of Modeling and Simulation in the Weapon System Acquisition Process. Washington D.C.: Director, Test, Systems Engineering and Evaluation, Department of Defense, 1996.

“Equipment and Support Systems Definition” excerpt on seizing technological opportunities. <http://www.bmpcoe.org/guideline/books/bestprac/002024fb.html>.

Etter, Paul C. *Underwater Acoustic Modeling and Simulation*. 3rd ed. London ; New York: Spon Press, 2003.

Evans, Jimmy, “Navy Strategic Planning Process for Science and Technology Demonstrations: Transitioning R&D Advanced Technology into the Fleet,” *Program Manager*. July-August 2000.

“Federal Grant and Cooperative Agreement Act of 1997,” P.L. 95-224. Subsequently recodified as Chapter 63 of P.L. 97-258 (31 U.S.C. 6301 et seq.).

Federal Register on “New Challenge Program”

<http://www.mailgate.org/gov/gov.us.fed.dod.announce/msg01106.html>.

Fellows, James, “Councils of War,” *The Atlantic Monthly*. February 2002.

Fiorino, Thomas D., Sr. Vice President, Andrulis Corporation, “Engineering Manufacturing Readiness Levels: A White Paper,” October 30, 2001.

Fishwick, Paul A. *Handbook of Dynamic System Modeling*. Chapman & Hall/CRC computer and information science series. Boca Raton: Chapman & Hall/CRC, 2007.

Forsberg, K., H. Cotterman, and H. Mooz. *Visualizing Project Management: A Model for Business and Technical Success*. New York: Wiley, 2000.

“From Beginning to End: The Life Cycle of Technology Products,” *The Wall Street Journal*. October 15, 2001.

General Accounting Office, “Best Practices: Better Management of Technology Development Can Improve Weapon System Outcomes.” Report number GAO/NSIAD-99-162, July 30, 1999.

General Accounting Office, “Best Practices: DoD Can Help Suppliers Contribute More to Weapons System Programs.” Report number GAO/NSIAD-98-87, March 17, 1998.

General Accounting Office, “Best Practices: Successful Application to Weapon Acquisitions Requires Changes in DoD’s Environment,” Report to the Subcommittee on Acquisition and Technology, Committee on Armed Services, U.S. Senate. February 1998, Report Number GAO/NSIAD-98-56.

General Accounting Office, “Defense Manufacturing Technology Program: More Joint Projects and Tracking of Results Could Benefit Program,” Report to Congressional Committees, September 2001, Number GAO-01-943.

General Accounting Office, “DoD Research—Acquiring Research by Nontraditional Means,” Report Number NSIAD-96-11, March 29, 1996.

General Accounting Office, “Export Controls: Clarification of Jurisdiction for Missile Technology Items Needed,” Report to the Subcommittee on Readiness and Management Support, Committee on Armed Services, U.S. Senate. October 2001, Report Number GAO-02-120.

General Accounting Office, “Intellectual Property: Industry and Agency Concerns over Intellectual Property Rights,” Report # GAO-02-723T, dated May 10, 2002. Testimony by Jack L. Brouck, Jr., Managing Director, Acquisition and Sourcing Management, before the Subcommittee on Technology and Procurement Policy, Committee on Government Reform, House of Representatives.

General Accounting Office, "Joint Strike Fighter Acquisition: Mature Critical Technologies Needed to Reduce Risks," October 19, 2001.

General Accounting Office, "NASA: Better Mechanisms Needed for Sharing Lessons Learned." Report to the Subcommittee on Space and Aeronautics, Committee on Science, House of Representatives. Report number GAO-02-195, January 2002.

General Accounting Office, "National Laboratories: Better Performance Reporting Could Aid Oversight of Laboratory-Directed R&D Program." Report to Congressional Requesters, September 2001, No. GAO-01-927.

General Motors Corporation. "Virtual Factory Enabled GM to Save Time and Costs in Desing of Lansing Grand River Assembly," News Release, January 9, 2002.

*Government Executive*, "The Only Game in Town: Now government is America's hottest technology market," December 2001.

GovExec.com, "The Top Government Purchasers - Navy," August 1, 2001.

Graham, Margaret B.W., and Alec T. Shuldiner, *Corning and the Craft of Innovation*. New York: Oxford University Press, 2001.

Haines, Linda, "Technology Refreshment within DoD: Proactive Technology Refreshment Plan Offers DoD Programs Significant Performance, Cost, Schedule Benefits," *Program Manager*. March-April 2001.

Harrington, Gia, Office of Naval Research, "Managing Disruptive Technologies and Innovations," New Haven, Conn.: Harvard University, John F. Kennedy School of Government, November 19-20, 2001.

Hollenbach, J.W. "Department of the Navy (DON) Corporate Approach to Simulation Based Acquisition," in Proceedings of the Fall 2000 Simulation Interoperability Workshop in Orlando, Fla., September 17-22, 2000.

\_\_\_\_\_. "Collaborative Achievement of Advanced Acquisition Environments," in Proceedings of the Spring 2001 Simulation Interoperability Workshop, Orlando, Fla., March 25-30, 2001.

Hollis, W.W., and A. Patenaude. "Simulation Base Acquisition: Can We Stay the Course," *Army RD&A* (May-June 1999), pp. 11-14.

Hundley, Richard O., "DARPA Technology Transitions: Problems and Opportunities," Project Memorandum prepared for DARPA. National Defense Research Institute: June 1999. Report number PM-935-DARPA.

- IEEE Circuits and Systems Society. *BMAS 2003 : Proceedings of the 2003 IEEE International Workshop on Behavioral Modeling and Simulation : San Jose, California, October 7-8, 2003*. San Jose, Calif; Piscataway, NJ: IEEE, 2003.
- Ince, A. Nejat, and Ercan Topuz. *Modeling and Simulation Tools for Emerging Telecommunication Networks : Needs, Trends, Challenges and Solutions*. New York: Springer, 2006.
- “Independent Research and Development (IR&D), Information for DoD Personnel,” brochure published by Defense Technical Information Center, Fort Belvoir, Va.
- John, Vicki L., “Department of Defense (DoD) and Industry—A Healthy Alliance,” thesis, Naval Postgraduate School, Monterey, California. June 2001.
- Joint Chiefs of Staff, *Joint Vision 2010: Focused Logistics: A Joint Logistics Roadmap*.
- Jones, Jennifer, “Moving into Real Time: Enterprises can now do business with up-to-the-minute data feeds, but getting all the pieces in place may be challenging,” *InfoWorld*. January 21, 2002, vol. 24, issue 3.
- Kang, Keebom and R.J. Roland, “Military Simulation,” in *Handbook of Simulation* (ed. J. Banks), New York: Wiley, 1998, pp. 645-658.
- Kuipers, Benjamin. *Qualitative Reasoning : Modeling and Simulation with Incomplete Knowledge*. Artificial intelligence; variation: Artificial intelligence Cambridge, Mass: MIT Press, 1994.
- Ladner, Roy, and F. Petry. *Net-Centric Approaches to Intelligence and National Security*. New York: Springer Science+Business Media, 2005.
- Laguna, Manuel, and Johan Marklund. *Business Process Modeling, Simulation, and Design*. Upper Saddle River, N.J: Pearson/Prentice Hall, 2005.
- Lucas, T.W. “Credible Uses of Combat Simulation: A Framework for Validating and Using Models,” RAND P7990, 1997.
- Mayr, Herwig. *Virtual Automation Environments : Design, Modeling, Visualization, Simulation*. New York: Marcel Dekker, 2002.
- Melin, Patricia, and Oscar Castillo. *Modeling, Simulation and Control of Non-Linear Dynamical Systems : An intelligent Approach using Soft Computing and Fractal theory*. v. 2. London; New York: Taylor & Francis, 2002.
- Mielke, Alexander. *Analysis, Modeling and Simulation of Multiscale Problems*. Berlin; New York: Springer, 2006.

Morrow, Walter E., Jr., "Summary of the Defense Science Board Recommendations on DoD Science & Technology Funding." Washington, D.C.: Office of the Secretary of Defense, June 1, 2000.

MORS (Military Operations Research Society). *Test & Evaluation, Modeling and Simulation and VV&A: Quantifying the Relationship Between Testing and Simulation*. MORS Workshop, The Energy Training Complex, Kirtland Air Force Base, Albuquerque, New Mexico, 15-17 October, 2002.

Motaghedi, Pejmun, Society of Photo-optical Instrumentation Engineers, Inc Optech, and Ball Aerospace & Technologies Corporation (USA). *Modeling, Simulation, and Verification of Space-Based Systems II* Proceedings of SPIE. v. 5799; variation: Proceedings of SPIE--the International Society for Optical Engineering. v. 5799. Bellingham, Wash: SPIE, 2005.

National Center for Advanced Technologies, "COSSI 'Executive Roundtable' Independent Assessment," June 11, 2001.

National Center for Advanced Technologies, "An Evaluation and Assessment of the DoD Commercial Operations & Support Savings Initiative: Final Report of the DoD COSSI Program Independent Assessment Executive Roundtable," Report Number 01-CO1A. Washington, D.C.: September 2001.

National Center for Advanced Technologies, "An Evaluation and Assessment of the DoD Dual Use Science & Technology Program: Final Report of the DoD Dual Use Science and Technology Program Independent Assessment Panel," Report Number 01-1A. Washington, D.C.: June 2000.

National Center for Advanced Technologies, "Toward More Affordable Avionics: An Industry Perspective," final report of the Affordable Avionics Initiative Working Group. Washington, D.C.: November 2001. Report No. 01-AAI-1.

National Research Council, Board on Science, Technology, and Economic Policy, *The Small Business Innovation Research Program SBIR: An Assessment of the Department of Defense Fast Track Initiative*. Washington, D.C.: National Academy Press, 2000.

National Research Council. Committee on Modeling and Simulation Enhancements for 21st Century Manufacturing and Acquisition. *Modeling and Simulation in Manufacturing and Defense Systems Acquisition : Pathways to Success*. The Compass Series. Washington, D.C: National Research Council, 2002.

National Research Council. Committee on Modeling and Simulation for Defense Transformation. *Defense Modeling, Simulation, and Analysis : Meeting the Challenge*. Washington, D.C: The National Academies Press, 2006.



National Research Council, "Equipping Tomorrow's Military Force: Integration of Commercial and Military Manufacturing in 2010 and Beyond." Report by the Committee on Integration of Commercial and Military Manufacturing in 2010 and Beyond, Board on Manufacturing and Engineering Design, Division on Engineering and Physical Sciences. Washington, D.C.: National Academy Press, 2002.

National Science Foundation, National Patterns of R&D Resources: 1996—An SRS Special Report, Division of Science Resources Studies, Directorate for Social, Behavioral, and Economical Sciences.

National Technology Alliance, "National Technology Alliance: The First Decade 1987 - 1997," National Imagery and Mapping Agency: Bethesda, Maryland.

National Technology Alliance, "National Technology Alliance: Accomplishments & Projects 1997 - 1998," National Imagery and Mapping Agency: Bethesda, Maryland, January 1999.

National Technology Alliance, "National Technology Alliance: Strategic Business Areas," Printed by National Imagery and Mapping Agency: Bethesda, Maryland. Document No. 042600.

Nicol, David M., Christopher D. Carothers, Stephen J. Turner, Association for Computing Machinery, Special Interest Group in Simulation, IEEE Computer Society, Technical Committee on Simulation, and Society for Modeling and Simulation International. *Proceedings : Workshop on Principles of Advanced and Distributed Simulation (PADS 2005), Monterey, California, June 1-3, 2005*. Workshop on principles of advanced and distributed simulation. Los Alamitos, Calif: IEEE Computer Society, 2005.

Noor, Ahmed Khairy, and Langley Research Center. *Multiscale Modeling, Simulation and Visualization and their Potential for Future Aerospace Systems*. Training workshop on multiscale modeling, simulation, and visualization and their potential for future aerospace systems. NASA CP. 2002-211741; Hampton, VA: National Aeronautics and Space Administration, Langley Research Center, 2002.

Office of the Assistant Secretary of the Army, *Constructing Successful Business Relationships: Innovation in Contractual Incentives*. Prepared by Science Applications International Corporation.

Office of the Deputy Under Secretary of Defense for Acquisition Reform, Commercial Item Acquisition: Considerations and Lessons Learned. Washington, D.C.: July 14, 2000.

Office of the Deputy Under Secretary of Defense for Acquisition Reform, *Incentive Strategies for Defense Acquisitions*. Washington, D.C.: April 2001.

Office of the Inspector General, "Army Transition of Advanced Technology Programs to Military Applications," acquisition report number D-2002-107, June 14, 2002.

Office of Management and Budget, "Use of 'Share in Savings'," Circular A-11.  
<http://www.whitehouse.gov/omb/circulars/a11/a11.html>

Office of Management and Budget, "Grants and Cooperative Agreements with State and Local Governments," Circular A-102.  
<http://www.whitehouse.gov/omb/circulars/a102/a102.html>

Office of Management and Budget, "Uniform Administrative Requirements for Grants and Agreements with Institutions of Higher Education, Hospitals, and Other Non-Profit Organizations," Circular A-110.  
<http://www.whitehouse.gov/omb/circulars/a110/a110.html>

Office of the Secretary of Defense Cost Analysis Improvement Group, *Operating and Support Cost-Estimating Guide*. Washington, D.C., May 1992.

Office of the Secretary of Defense DDR&E, "Department of Defense Independent Research and Development (IR&D) Program Action Plan," November 2000.

Office of the Secretary of Defense, "New Challenge Program," Federal Register, Volume 64, Issue 71, Page 19744,  
<http://www.mailgate.org/gov/gov.us.fed.dod.announce/msg01106.html>.

Office of the Under Secretary of Defense for Acquisition and Technology, "Report of the Defense Science Board Task Force on Acquisition Reform Phase IV," July 1999.

Office of the Under Secretary of Defense for Acquisition & Technology, "Report of the Defense Science Board Task Force on Defense Science and Technology Base for the 21st Century." June 1998.

Olwell, David H., Jean M. Johnson, Jarema M. Didoszak, Joseph Cohn. "Systems Engineering of Modeling and Simulation for Acquisition Curricula," in Proceedings, The Interservice/Industry Training, Simulation & Education Conference (I/ITSEC), 2007.

Pace, D.K. "Issues Related to Quantifying Simulation Validation," in Proceedings of the Spring 2002 Simulation Interoperability Workshop, Orlando, Fla., March 10-15, 2002.

Pentland, Dr. Pat Allen, U.S. Commission on National Security/21st Century, "Creating Defense Excellence: Defense Addendum to Road Map for National Security, May 15, 2001. (Defense addendum to Hart-Rudman report)  
[www.nssg.gov/addendum/Creating\\_Defense\\_Excellence.pdf](http://www.nssg.gov/addendum/Creating_Defense_Excellence.pdf).

- Piplani, Lalit K., Joseph G. Mercer, Richard O. Roop. *Systems Acquisition Manager's Guide for the use of Models and Simulations* Fort Belvoir, Va.: Defense Systems Management Press, September 1994.  
[http://www.dau.mil/pubs/mfrpts/pdf/mod\\_sim.pdf](http://www.dau.mil/pubs/mfrpts/pdf/mod_sim.pdf)
- Proteus Group, LLC and Technology Strategies & Alliances, "Office of Naval Research Technology Transition Wargame Series: Organic Mine Countermeasures Future Naval Capabilities Wargame," After Action Report, May 28, 2002.
- Purdue, Thomas M., "The Transition of ACTDs—Getting Capability to the Warfighter: Demonstrating Utility Is Only Part of the Job," *Program Manager*. March-April 1997.
- Purdy, E. "Simulation Based Acquisition Lessons Learned: SMART Collaboration for Future Combat Systems," *SISO Simulation Technology*, Issue 75, June 20, 2001.
- Richardson, R. "Joint Virtual Battlespace," Proceedings of the SMART Conference, April 16-18, 2002.
- Robinson, S. "Simulation Verification, Validation and Confidence: A Tutorial," Transactions of the Society for Computer Simulation International, 1999, Vol. 16, No.2, pp. 63-69.
- Sage, A.P., and S.R. Olson. "Modeling and Simulation in Systems Engineering: Whither Simulation Based Acquisition?," *Modeling and Simulation Magazine*, March 2001.
- Schum, William K., Alex F. Sisti, and Society of Photo-optical Instrumentation Engineers. *Modeling and Simulation for Military Applications : 18-21 April, 2006, Kissimmee, Florida, USA*. Proceedings of SPIE. Bellingham, Wash: SPIE, 2006.
- Schrage, M. *Serious Play: How the World's Best Companies Simulate to Innovate* Cambridge, Mass.: Harvard Business School Press, 1999.
- Simon, H.A. and A. Newell. "Information Processing in Computer and Man," *American Scientist*, Vol. 52, pp. 281-300.
- Smith, Giles; Jeffrey Drezner; and Irving Lachow, "Assessing the Use of 'Other Transactions' Authority for Prototype Projects," Rand documented briefing prepared by the National Defense Research Institute for the Office of the Secretary of Defense, 2002.
- Tewari, Ashish. *Atmospheric and Space Flight Dynamics : Modeling and Simulation with MATLAB and Simulink*. Modeling and simulation in science, engineering and technology. Boston: Birkhäuser, 2007.

Under Secretary of Defense (Acquisition, Technology, and Logistics), “Evolutionary Acquisition and Spiral Development,” Memorandum. Washington, D.C.: April 12, 2002.

U.S. House of Representatives, “Small Business Innovation Research Program Act of 2000,” P.L. 106-554, Appendix 1—HR 5667, Title 1, accessed at <http://www.acq.osd.mil/sadbu/sbir/pl106-554.pdf> on August 1, 2002.

U.S. Joint Forces Command, “Joint Forces Command Glossary.” <http://www.jfcom.mil/about/glossary.htm#JE>.

Wu, Benjamin; Stanley Fry, Richard Carroll, Gilman Louie, Tony Tether, and Stan Soloway. Testimonies on “Intellectual Property and R&D for Homeland Security,” made at oversight hearing before the Subcommittee on Technology and Procurement Policy, Committee on Government Reform, House of Representatives, U.S. Congress, May 10, 2002.

Zeigler, Bernard P., Herbert Praehofer, and Tag Gon Kim. *Theory of Modeling and Simulation : Integrating Discrete Event and Continuous Complex Dynamic Systems*. 2nd ed. San Diego: Academic Press, 2000.

## 3.0 Conclusion

### **Compliance with statement of work:**

This report has presented the deliverables for 2007 for this project. The deliverables included the human capital strategy (deliverable 11.1 from the original statement of work (SOW)) and body of knowledge (deliverable 11.2 for the SOW) provided under separate cover by AFAMS. NPS deliverables included the content matrix and catalog of existing courses (deliverable 11.3 from the SOW), the learning architecture (deliverable 11.4), monthly status reports (deliverable 11.5), and presentations and technical papers for the proper socialization of the project (deliverable 11.6).

The catalog of existing courses was previously submitted in March 2007 in technical report NPS-SE-07-M01, WORKFORCE MODELING & SIMULATION EDUCATION AND TRAINING FOR LIFELONG LEARNING: MODELING & SIMULATION EDUCATION CATALOG, by Jean M. Catalano and Jarema M. Didoszak.

The content matrix is included in this report in section 2.1.

The learning architecture is included in this report in section 2.2-4.

Monthly status reports have been submitted to the program manager, CAPT Michael Lilienthal, USN, and to other interested parties. Copies are available upon request.

Presentations and technical papers have been delivered as outlined in section 1.6 of this report.

There are no remaining 2007 deliverables.

### **Impact**

This project has already had a significant impact upon the education of DoD personnel. The academic partner universities have re-examined their course offerings in response to the deficiencies noted in the gap analysis and are planning to offer the courses we develop in CY2008. This will have the immediate effect of increasing the number of educational opportunities available for the DoD workforce.

This project has generated demand for this education from the stakeholders, even from those who were initially unenthusiastic to the idea. The Army is requesting a two week short course in Monterey for selected content for its key managers, for example.

The syllabi developed for modules and courses are public domain, and offer a blueprint to any institution in the nation that wishes to start offering courses in these areas.

Our socialization efforts have produced strong expressions of interest from every audience to whom they have been presented.

## Issues and lessons learned

The business plan cannot be ignored when building curricula. This is the largest outstanding issue. When the project began, the original business plan was that the costs of delivery would be centrally funded. This changed to a customer-funded model as we got underway. The mechanics of that funding and revenue sharing are being worked out. Of greater importance, unless the workforce is presented with incentives to enroll in the curricula, there is a risk of low enrollment. The sponsor bears the responsibility to help create demand in the acquisition workforce, as that is beyond the scope of the project. The sponsor is considering adding the completion of the content of this program to the credentials necessary to advance in the acquisition workforce. This also involves risk, since there are many stakeholders involved in the management of the qualifications of the acquisition workforce, and the M&S CO is but one of them. The risk to the academic partners has been mitigated by paying them the full cost to develop their materials, but there is still risk to DoD if we “build it but they do not come.” Employees under DAWIA have a requirement for 80 hours of continuing education every two years, and that should provide some demand. However, if the MSSC truly wishes to influence the education of the workforce, it must facilitate the enrollment of students by providing career incentives for them to do so.

It has taken longer to build consensus among the wide group of stakeholders represented than we originally anticipated. The greater the number of partners, the less agile the effort. There is an enormous amount of coordination and synchronization necessary in an undertaking such as this. This requires much greater coordination than we had anticipated. Obtaining consensus is also difficult when team members have different visions.

Contracting has been a challenge, especially with regionalization of our contracting personnel.

The treatment of intellectual property has been especially thorny for the academic partners. We have insisted that all materials be ‘works made for hire’ under the provision of the copyright law, so that they may be freely distributed by the government.

Integration is emerging as a challenge. The curricula must be vertically and horizontally integrated. We acknowledge that there is risk when there are so many different delivering institutions involved. Our mitigation strategy is to provide templates and feedback. This still promises to be a challenge.

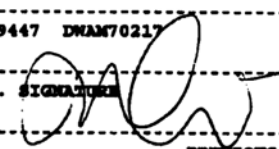
## Way ahead

We expect that sets of these courses will be tested in the summer of 2008, and that they will be widely available for residential, web-based, and short course instruction by the beginning of CY2009. We will develop the assessment plan in CY2008 for the longitudinal assessment of this effort and for estimation of the return on investment.

At the conclusion of this next year, we will have built an entirely new infrastructure for the education of the DoD workforce in the use of modeling and simulation. While this initial effort was focused on the acquisition and T&E workforces, the great majority of the material will generalize to the other communities and services.

The nation will be better able to “educate and train the workforce to achieve required M&S competencies”, which is the number one priority of the *Acquisition M&S Master Plan*.

## Appendix I

MILITARY INTERDEPARTMENTAL PURCHASE REQUEST				1. PAGE 1 OF PAGES	
2. FSC	3. CONTROL SYMBOL NO.	4. DATE PREPARED FEB 26, 2007	5. MIPR NO. DNAM70217	6. AMEND NO. BASIC	
7. TO: NAVAL POSTGRADUATE SCHOOL ATTN: YOLANDA FORRESTER 1 UNIVERSITY CIRCLE MONTEREY, CA 93943			8. FROM: DOD WASHINGTON HEADQUARTERS SERVICES PROGRAM/BUDGET DIVISION 1155 DEFENSE PENTAGON ROOM 3B269 WASHINGTON, D.C. 20301-1155		
9. ITEMS ARE ARE NOT INCLUDED IN THE INTERSERVICE SUPPLY SUPPORT PROGRAM AND REQUIRED INTERSERVICE SCREENING HAS HAS NOT BEEN ACCOMPLISHED.					
DESCRIPTION					TOTAL PRICE
THIS MIPR PROVIDES FUNDS FOR EDUCATING THE MODELING AND SIMULATION WORKFORCE. REF: DRE-3832-713A/DMSO-3832-07/PE0603832D8E FINANCIAL POC: YOLANDA FORRESTER 831-656-2247 EMAIL: YFORRESTER@NPS.MIL F 831-656-2843 PROJECT POC: CAPT MICHAEL LILIENTHAL 703-614-6432 EMAIL: MICHAEL.LILIENTHAL@NAVY.MIL *STATEMENT OF WORK INCLUDED.					\$975,000.00
REIMBURSABLE FUNDING ONLY: IF THESE FUNDS ARE NOT ACCEPTED AS CATEGORY I (REIMBURSABLE) ON THE ATTACHED DD FORM 448-2, THE MIPR MUST BE RETURNED AS "NOT ACCEPTED", CHECKING BLOCK 7. *** FUNDS MAY NOT BE REDIRECTED. *** ACCEPTOR MUST BE PERFORMER.					
THESE FUNDS ARE PROVIDED ON A REIMBURSABLE BASIS AND NO OBLIGATIONS MAY BE INCURRED AFTER 09/30/08 AND SUBJECT THEREAFTER TO FMR7000.14 EXTENSION RESTRICTIONS. THESE FUNDS MAY NOT BE DIRECT CITED FOR GOVERNMENT TRAVEL PURPOSES. DOD-WHS POC: BENEDICTA DEGUZMAN COMM: (703) 699-3367 OR DSN: 229-3367 EMAIL: BENEDICTA.DEGUZMAN@WHS.MIL FAX: (703) 699-3082 OR DSN: 329-3082					
FORWARD FORMAL ACCEPTANCE, OBLIGATION AND BILLING DOCUMENTS TO ADDRESS SHOWN IN ITEM 13. *** DOD-WHS WILL NOT BE ASSIGNED AS PAYING OFFICE FOR ANY RESULTING CONTRACTS. ***					
10. SEE ATTACHED FOR DELIVERY SCHEDULES, PACKAGING AND SHIPPING INSTRUCTIONS AND INSTRUCTIONS FOR DISTRIBUTION OF CONTRACTS.					11. GRAND TOTAL \$975,000.00
12. TRANSPORTATION ALLOTMENT (USED IF FOB CONTRACTOR'S PLANT)			13. MAIL INVOICES TO: DEFENSE AGENCIES - INDIANAPOLIS OPS ATTN: DFAS-DAIO DAFS Rm 2041-2 8899 E 56th Street PT 3800 Indianapolis IN 46249-1500		
14. FUNDS FOR PROCUREMENT ARE PROPERLY CHARGEABLE TO THE ALLOTMENTS SET FORTH BELOW. THE AVAILABLE BALANCE OF WHICH ARE SUFFICIENT TO FUND THE ESTIMATED TOTAL PRICE.					
ACCOUNTING CLASSIFICATIONS					AMOUNT
97 70400.1120 P7476 0401 2599 849447 DNAM70217					\$975,000.00
15. AUTHORIZING OFFICER Benedicta DeGuzman CKT. OFF., DOD-WHS			16. SIGNATURE 		17. DATE FEB 26, 2007

DD FORM 448 1 JUN 72

PREVIOUS EDITION IS OBSOLETE.



## Appendix II

### STATEMENT OF WORK for Educating the M&S Workforce

#### 1.0 SCOPE.

The purpose of this work effort is to support the Department of Defense (DoD) Modeling and Simulation (M&S) program in the development of a program for lifelong learning in M&S.

#### 2.0 BACKGROUND.

As identified in the Modeling and Simulation Steering Committee Common and Cross-Cutting Business Plan (MSSC C&CC BP), it is widely recognized that “the M&S workforce is not equipped with adequate education, processes, practices, tools, technology and resources to support the institutionalization of M&S across the DoD’s mission space.” A review of DoD M&S workforce requirements, including development of required professional competencies, and consolidation of multiple M&S bodies of knowledge is needed. Additionally, education, training, refresher training, continuing education, and certification opportunities may all be needed to improve multi-service community members’ abilities to select and use M&S tools effectively and efficiently.

This SOW provides for the development of a Human Capital Strategy that includes education and training for preparing DoD professionals to apply M&S appropriately and effectively. The work will result in a learning architecture designed to “educate and train the workforce to achieve required M&S competencies”, which is the number one priority of the *Acquisition M&S Master Plan*. From this instructional framework, curricula and effectiveness evaluation criteria can be developed for use throughout the DoD professional education system. The curriculum development and evaluation programs are not a part of this SOW, and will be proposed as future tasking.

#### 3.0 REQUIREMENTS.

The following tasks are designed to accomplish the objectives (purpose) for this work effort:

**3.1** Collect and review other organizations M&S Workforce Analyses. Identify gaps and conduct data collection to cover the rest of DoD. Based on data, develop the formal written M&S Human Capital Strategy for DoD. (Primary performer: AFAMS)

**3.2.** Collect and review all known M&S Bodies of Knowledge. Consolidate a Joint DoD M&S Body of Knowledge and validate through Communities and Services. (Primary performer: AFAMS)

**3.3** Develop and refine the needs assessment and content requirements for an educational program, derive guidelines for linking training content to participants’ specific knowledge gaps, review existing service needs assessments, and conduct AoA to develop a learning matrix that provides instructional content for different educational/experiential backgrounds of the workforce. (Primary performer: NPS)

**3.4** Based on deliverables from 3.1 through 3.3, develop a learning architecture identifying learning element content guidelines, programmatic scope and specific instructional delivery modes to address the gaps identified in the learning matrix. (Primary performer: NPS)

**3.5** Provide monthly reports on task progress and total expenditures. (Both AFAMS and NPS to provide)

**4.0 KEY PERSONNEL.** Each performing team will provide an analyst to support all aspects of this effort. As a minimum, lead investigators must have an undergraduate degree in mathematics, physics, computer science, or other related technical discipline. Graduate work in the field of application or a

minimum of ten years of experience is required for lead investigators. Supporting researchers should have the same undergraduate qualifications, but with graduate degrees or five years of experience.

**5.0 PLACE OF PERFORMANCE.** Primary place of performance will be the primary performer facilities. These include both the Naval Postgraduate School in Monterey, CA, and the Air Force Agency for Modeling and Simulation in Orlando, FL. Team members will meet in alternative locations as necessary to perform and promote this work, and will present status and technical information to the M&S SC and Acquisition Modeling and Simulation Working Group (AMSWG) at designated locations as required.

**6.0 SECURITY CLEARANCE.** This work is unclassified. No security clearances are required.

## **7.0 GOVERNMENT FURNISHED EQUIPMENT/GOVERNMENT FURNISHED**

**INFORMATION (GFE/GFI).** Government direction will be provided as specified together with access to other DMSO programs as required by the tasking and determined by the cognizant DMSO POC. The same is true for the acquisition of property needed for the performance of the tasks in this statement of work.

**8.0 TRAVEL.** All travel required during the performance of this task order shall adhere to the Federal Travel Regulations (for travel in 48 contiguous states), the Joint Travel Regulations, Volume 2, DOD Civilian Personnel, Appendix A (for travel to Alaska, Hawaii, Puerto Rico, and U.S. Territories and possessions), and if required by the SOW, the Standardized Regulations (Government Civilians, Foreign Areas), Section 925, approved by the DMSO Deputy Director of Technology, or her designated appointee, Maximum Travel Per Diem Allowances for Foreign Areas (for travel not covered in the Federal Travel Regulations or Joint Travel Regulations). All travel will be coordinated and approved prior to actual travel. Local travel is required.

**9.0 MATERIALS.** The performing activities may be required to furnish material for the completion of this task as directed by the M&S SC and AMSWG.

**10.0 PERIOD OF PERFORMANCE.** The completion of all deliverables under this task will take approximately seven (7) months from start-up. Upon successful completion of this tasking, the performers will request follow on tasking to develop curriculum and evaluation criteria. In no case, however, shall the Government be obligated to fund follow on work.

## **11.0 DELIVERABLES.**

**11.1** The tasking identified in 3.1 will result in a written M&S Human Capital Strategy for DoD.

**11.2** The tasking identified in 3.2 will result in a Joint DoD M&S Body of Knowledge.

**11.3** The tasking identified in 3.3 will result in a Content Matrix, as well as supporting documentation including a catalog of existing M&S education opportunities available to the M&S workforce.

**11.4** The tasking identified in 3.4 will result in a Learning Architecture.

**11.5** Monthly status reports.

**11.6** Presentations and technical papers as deemed necessary for the proper socialization of the work performed as part of this SOW.

## Distribution List

1. Defense Technical Information Center  
Ft. Belvoir, Virginia
2. Dudley Knox Library  
Naval Postgraduate School  
Monterey, California
3. Mr. Bill Zimmerman  
1333 Isaac Hull Avenue SE, Stop 5012  
Washington Navy Yard, D.C. 20376-5012
4. Mr. Chris DiPetto  
Office of the Under Secretary of Defense (AT&L)  
Deputy Director, Developmental Test & Evaluation  
3090 Defense Pentagon, Room 2B278  
Washington, DC 20310-3090
5. Mr. Robert Butterworth  
4850 Mark Center Drive, Suite 10501  
Alexandria, VA 22311
6. Ms. Annie Patenaude (Training)  
Director, Joint Assessment & Enabling Capability  
1901 N. Beauregard St, Suite 600  
Alexandria, VA 22311
7. Mr. Bexfield (PA&E)  
Office of the Secretary of Defense  
Program Analysis & Evaluation (PA&E)  
1800 Defense Pentagon, Room 2D279  
Washington, DC 20301
8. Mr. Mike Truelove  
SAIC Support  
Developmental Test & Evaluation (OUSD(AT&L))  
1550 Crystal Drive, Suite 1004  
Arlington, VA 22202